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TEST-TUBE FRUITS AND SEEDS*

By P. Maheshwari

Delhi University

I am deeply conscious of the honour which the Indian Botanical Society has done me in awarding the Birbal Sahni Memorial Medal of 1958. I greatly cherish the memory of Professor Sahni. While my contacts with him were few, they lasted in some form or the other right from the time I began work as a student for the D.Sc. degree of the University of Allahabad in 1927 to the time of his death in 1949. For a couple of months in 1939 I was also his colleague at the Lucknow University. Fate took me away then to the University of Dacca and it is only after a period of ten years that I returned this side to Delhi. I recall with great pleasure the moral support and encouragement which I always received from Professor Sahni. I am also reminded today of the late Dr. Winfield Dudgeon, of the Ewing Christian College, Allahabad, who was the Founder-President of the Indian Botanical Society and at whose feet I not only learnt my first lessons in botany but also worked for my doctorate. To him my heart turns today in gratitude as it is he more than anyone else who made me what I am.

With this humble tribute to two eminent persons whom I consider to be my *gurus*, I now turn to the subject of my address, 'Test-tube Fruits and Seeds'.

While we all know in general terms what a fruit is, the morphological, physiological and chemical changes which occur in the ovary during its conversion into a fruit are not yet fully understood. In fact it must have been a source of wonder to the ancients as to what caused the ovaries of some flowers to start growing suddenly to many times their original size, as in a pumpkin, while ovaries of other flowers (the unpollinated ones) on the same plant fell off without producing anything.

From the botanist's point of view it is fortunate that a plant like the date-palm has been grown on a large scale for many hundred years by the inhabitants of the Middle East. They probably did not take very long to find that there are two kinds of palms: those which bear fruit and are fertile, and others which do not bear any fruits and are,

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therefore, sterile. The former were recognized as females and the latter as males. The ancients also observed that in the absence of the second type even the first remain sterile. A series of further observations and some intuition must have led them to the practice of artificial pollination, for Herodotus (484–425 B.C.) tells us that the Arabs and the Assyrians used to have a special ceremony at a certain time of the year when the high priest walked at the head of a procession and touched the female flowers with the male inflorescences in order to ensure a good supply of dates.

Pliny (23–79 A.D.), in one of the 37 volumes of his *Natural History*, devoted about a page to the relation between the male and the female date-palms and said that the male palm with its erect leaves has somewhat of a military bearing while the females with their softer foliage and feminine ways bend towards it to save themselves, as it were, from the curse of virginity or widowhood. It was thought at that time that the very breath of the male plants or at any rate the dust from them was enough to render the females fertile.

For many years after this no one seems to have bothered about the problem of sexuality and fruit formation in plants, until Camerarius (1694), Director of the Botanical Garden at Tübingen, performed a number of decisive experiments to show that fruit and seed formation are dependent upon pollination and that the production of that marvellous thing in nature, the seed, which is the beginning of a new generation and the means of maintenance of the species, does not take place unless the anthers have previously prepared the young plant contained in the ovary. He made it clear that pollen is essential for the maturation of the fruit and the seed but did not know how it produced such an effect.

The next great advance came in the years between 1824 and 1830 when an Italian astronomer, mathematician and microscope-maker, named Amici, discovered that the pollen grains give out pollen tubes which travel all the way into the style and the ovary and finally enter the ovules, one tube for each ovule. Hofmeister (1847) demonstrated that the pollen tube discharges its contents in the embryo-sac and activates a pre-existing cell, the egg, to develop into an embryo. Concurrently, the ovule grows into a seed and the ovary into a fruit. Hofmeister thought that the touch-off of this remarkable chain of events owed itself to a liquid which diffused out of the pollen tube, but some years later Strasburger (1884) discovered syngamy and Nawaschin (1898) announced "double fertilization". During the same period a good deal came to be known of the behaviour of the chromosomes in mitosis and meiosis.

The gaseous exhalations of Pliny gave place to liquid discharges; the liquids gave place to solid or semi-solid substances like nuclei and then came the chromosomes and genes. These latter aroused so much interest that little importance was attached to Hofmeister's rather inadvertent statement about the diffusion of a chemical substance from the pollen tube into the embryo-sac.

However, there were a few other observations which gradually led to a better understanding of the chemical role of pollen. During the course of his hybridization experiments Gärtner (1849) once placed some lycopodium powder (spores of *Lycopodium*) on the stigmas of cucurbits and noted a distinct increase in the size of the ovary although the ovules did not grow further. Some fifty years latter Massart (1902), in Belgium, placed dead pollen on the stigma of an orchid and obtained a slight increase in the size of the ovary. Fitting (1909), working at the Bogor Botanical Gardens, made a further advance by showing that similar results could be obtained through the use of aqueous extracts of pollen. Yasuda (1934) injected extracts of pollen into the ovaries of some members of the Solanaceæ and Cucurbitaceæ and for the first time obtained some fruits matching those which resulted after pollination. Following the development of the *Avena* technique, Laibach (1932) and Thimann (1934) could easily detect that pollen contains growth hormones. The next step was taken by Gustafson (1936) who omitted the use of pollen and induced fruit formation through treatments with synthetic hormones alone. Since then this knowledge has already been put to economic use in the culture of greenhouse tomatoes in the winter season in Europe and America.

The observations made from the time of the ancient Arabs to the year 1936 may then be summarized as follows:—

1. Unpollinated ovaries normally produce neither fruits nor seeds but fall off.

2. Pollinated ovaries produce fruits *with* seeds.

3. Ovaries pollinated with dead pollen or treated with extracts of pollen produce fruits but these are seedless.

4. Ovaries treated with certain chemicals can also produce fruits but these too are seedless.

From the above it may be concluded that pollen performs two separate and independent functions. First, it provides the male gametes for double fertilization which is the starting point for the development of the embryo and endosperm. Secondly, it releases certain chemicals which stimulate the ovary wall to grow into the pericarp or cause the production of other substances which bring about such an effect.

While hormones are important agents in promoting fruit growth, they are not the only substances required by the ovary. Hitherto, the chief method open to physiologists to study such factors was to supply specific fertilizers to the soil around the plants or set up sand cultures and then observe what happened to the fruits. Useful information was also provided sometimes by ringing experiments and by cutting off the leaves in the vicinity of the fruits.

In science one type of work often gives a lead to another and fruit physiology is no exception. In 1924 a German botanist, K. Dietrich, wrote a significant paper entitled "Über Kultur von Embryonen ausserhalb des Samens" in which he described his successes with the

artificial culture of the embryos of plants belonging to several families of angiosperms. The embryos were excised from the ovules at a young stage and cultured on Knop's solution + 5–10% sucrose solidified with 1·5% agar. Now this is much like a Caesarean operation in which a young embryo is removed from the mother's womb and reared outside it. Caesar was born this way and hence the name given to this technique. No one performs such an operation except in special circumstances; and yet if we want to understand the nutritive requirements of the embryo, it is hardly possible to know them without excising it and then growing it to maturity under artificial conditions. It is reasonable to assume that what happens outside is a close approach to what might be happening inside the mother's body. It is not possible to take such liberties either with the mothers or with the babies inside them, but it is possible to experiment upon rats, rabbits and guinea-pigs. With plants there is no difficulty so far as material for experimentation is concerned but the precautions to be used in handling it are in no way less stringent due to the usual contamination by bacteria and fungi. Earlier, Kotte (1922) in Germany and Robbins (1922) in New York made cultures of root tips and in 1939 three independent workers—R. J. Gautheret in Paris, Pierre Nobecourt at the University of Grenoble, France, and P. R. White at the Rockefeller Institute of Medical Research in Princeton, N. J.—laid the *in vitro* culture technique on a firm foundation. In the past 20 years these studies have blossomed into an important experimental discipline of tissue and organ culture which the Botany Department of the Delhi University has taken up with much enthusiasm.

The success achieved in the culture of excised roots, cambial tissues and shoot apices, led other persons to try similar techniques with flowers and then with excised ovaries and ovules. The first notable work on the culture of ovaries is that of Nitsch (1951) who grew them in test-tubes without any contact with the mother plant. He reared ovaries of tomatoes and gherkin in artificial media. The fruits *in vitro* were usually much smaller than those *in vivo* and the seeds were often arrested in their development but the growth curves were of the same sigmoid type as those of fruits attached to the plant. Only in gherkin a few viable seeds were obtained.

The work at Delhi University was started with a view to obtain normal growth of excised ovaries and then to see in what way we could hasten it by manipulations of the environment. Later the work was extended to ovules.

While it might have been more interesting to culture the ovaries of economic plants, this was not possible due to lack of land for growing them in sufficient quantity. We had to satisfy ourselves with such plants as were being grown already for teaching or decorative purposes in the University grounds. This cannot, however, be considered any serious disadvantage because the general principles are the same and the knowledge and experience gained with these plants can easily be applied to crop plants.

Among the ovaries on which we worked may be mentioned: *Althæa rosea* (Chopra, 1958), *Aerva tomentosa* (Murgai, 1959), *Iberis amara* (N. Maheshwari and Lal, 1958), *Linaria maroccana* (Sachar and Baldev, 1958), *Ranunculus sceleratus* (Sachar and Guha, 1959), *Tropæolum majus* (Sachar and Kanta, 1958).

Briefly, the technique used by us is as follows: A flower is cut away from the plant and the ovary excised from it and sterilized by dipping for a few minutes in calcium hypochlorite. After this it is implanted on a suitable nutrient medium. One of the most troublesome things is the contamination with micro-organisms which are always present in the air and on the surface of the ovary. Special rooms are, therefore, required for the dissection of plant parts, preparation of media, inoculation, and storage of the cultures. For critical work it is also necessary to have a phytotron or a set of rooms in which temperature, humidity and light can be controlled. Unfortunately we had none of these facilities. We have done our work mostly in the winter season at room temperature which naturally fluctuates not only every week but every hour of the day and night. Nevertheless, some interesting results have been obtained and these are summarized in the following account.

Normally the culture medium comprised (*a*) the major elements: $Ca(NO_3)_2.4H_2O$—500 mg./l., KH_2PO_4—125 mg./l., KNO_3—125 mg./l., $MgSO_4.7H_2O$—125 mg./l.; (*b*) the trace elements: $CuSO_4.5H_2O$—0·025 mg./l., H_3BO_3—0·5 mg./l., $MnSO_4.4H_2O$—3·0 mg./l., $Na_2MoO_4.2H_2O$—0·025 mg./l., $ZnSO_4.7H_2O$—0·5 mg./l.; (*c*) $FeC_6O_5H_7.5H_2O$—10 mg./l. as iron source; (*d*) the amino acid glycine 7·5 mg./l. and the vitamins calcium pantothenate 0·25 mg./l., niacin 1·25 mg./l., pyridoxine hydrochloride 0·25 mg./l., thiamine hydrochloride 0·25 mg./l. 5% sucrose was added as the carbon source and generally the medium was solidified with 0·7% Bacto Difco agar. For further details about the preparation of the medium a reference may be made to the works of White (1943) and Nitsch (1951).

The culture solution was prepared by dissolving 50 gm. of sucrose in 500 ml. of double distilled water and adding to this 100 ml. of solution A, 1 ml. each of solutions B and C, and 5 ml. of solution D. After this, it was made up to 1 litre with double distilled water. This liquid medium was in most cases gelled with agar to give it a semi-solid consistency.

Although a fair measure of success was obtained with the ovaries of several species, *Iberis amara* (N. Maheshwari and Lal, 1958) is chosen here for illustration because this proved to be the easiest to culture (Plate III, Figs. 1, 2). The plant flowers profusely and plenty of material was available for experimentation. In nature the ovaries increase to twice their initial size within a week after pollination and attain their maximum size at the end of two weeks. Further changes, such as the differentiation of the pericarp and the maturation of the seeds, continue for another week. We experimented with flowers taken one day after pollination. Microtome sections showed that at this stage the ovules contain a zygote

or a 2-celled proembryo and a varying number of endosperm nuclei. Ovaries were cultured in the following: (1) water, (2) sugar + agar, (3) sugar + agar + minerals (made according to Nitsch's formula), (4) sugar + agar + minerals + vitamins (Nitsch's formula); (5) sugar + agar + minerals + vitamins + IAA; and some other variations.

In the two sets maintained in water, one with individual flowers and the other in which whole inflorescences were taken, growth ceased at the end of one week. In individual flowers there was no growth of either the embryo or the endosperm. In inflorescences the embryo developed to the globular stage but the endosperm had started degenerating. Ovaries, which were sown on the medium consisting of 5% sugar and 0·8% agar, grew to twice their initial size in 13 days but the fruits were cartilaginous and the thin, papery seeds contained neither the endosperm nor the embryo. On the addition of minerals (Nitsch's formula) the average size of the fruits after two weeks' growth was only slightly less than that of fruits *in vivo*. The addition of vitamins brought about a further improvement. Ovaries grew to about twice their size in one week. After this they started yellowing (an indication of ripening which compared well with the condition in nature) and the seeds became brownish. The development of the endosperm and embryo was quite comparable with that in nature. On adding IAA (5 mg./l.) to Nitsch's basic medium some fruits were obtained which were even larger than those in nature.

It is important to note, however, that when the calyx and corolla were removed (they persist for well over a week after fertilization), the growth of the ovaries always received some setback. Ovaries with the sepals and petals intact always outgrew those without them. This shows that the sepals and petals are by no means the unessential organs as described in text-books but have an important role in the physiology of the fruit.

Many other ovaries have been successfully cultured, and in *Althæa*, *Linaria*, *Zephyranthes* and *Ranunculus* (Plate IV, Figs. 4, 5) the ovules matured into seeds with viable embryos.

The fact that in several plants we were able to raise fruits of normal size *in vitro* and also obtain viable seeds may be considered to be a significant advance over Nitsch.

From test-tube fruits to test-tube seeds was our next step. The plants which proved most suitable for this purpose was *Papaver somniferum*, the opium poppy (N. Maheshwari, 1958). Young capsules were excised from the plant and surface-sterilized by dipping in rectified spirit and flaming. The capsule was then cut open under sterile conditions and a portion fixed immediately to note the exact stage of development; from the remaining part the ovules were scooped out and sown in Nitsch's medium supplemented with vitamins. In the basic medium the ovules containing a two-celled proembryo and free nuclear endosperm grew to maturity in 23 days. This was interesting but not quite satisfactory because in nature similar devlopment

takes place in 18 days. When the basic medium was supplemented with kinetin (0·4 mg./l.) and IAA (5 mg./l.) growth was faster; in 9 days after planting the ovules showed globular embryos and cellular endosperm and in 23-day old cultures the seeds had not only fully mature embryos but some had also germinated to produce seedlings which were normal except that the radicle showed localised swellings (Plate III, Fig. 3).

The work on ovaries and ovules encouraged us to try portions of ovules to see if these could be cultured to give rise to plants. We selected for this purpose the nucelli of *Citrus microcarpa*, an ornamental shrub available in the University Garden. The reason for this choice lay in the fact that in nature the nucelli of most species of *Citrus* give rise to adventive embryos. We wanted to explore this proliferative capacity of the nucelli in test-tubes on artificial media. The upper part of the young nucelli of fertilized ovules, which had begun to form proembryos, was cut out and inoculated on White's medium supplemented with trace elements (Nitsch, 1951) and cobalt chloride (0·025 p.p.m.). On this medium the nucelli failed to grow, but on adding casein hydrolysate (400 p.p.m.) to the medium there was profuse proliferation. The original nucellar tissue could hardly be observed after 6–8 weeks and there were seen instead numerous pearly, parenchymatous masses which we have called pseudobulbils (Plate IV, Fig. 6). Ranga Swamy (1958) has subcultured and maintained them for two years through transfers to fresh media. Kinetin (2 p.p.m.) enhanced the production of the pseudobulbils. The most significant part of this study was that after a couple of months many of the pseudobulbils gave rise to seedlings (Plate IV, Fig. 7). This clone in continuous culture is an important achievement. Here we have a method of obtaining an indefinite number of plants of the same genetic composition as the maternal parent. When this technique is standardized, it can be used to provide horticulturists with uniform material (*see* Maheshwari and Ranga Swamy, 1959).

All the work described above concerns only fertilized ovaries and ovules. When unpollinated ovaries were cultured, we obtained fruits only on the addition of auxins to the culture medium. This confirms the role of hormones in the growth of the ovary but the fruits thus obtained had either no seeds or the seeds were devoid of embryos. Biologists have long laboured to find a method of causing unfertilized eggs to develop into new individuals. If we are to believe all that is written in the scriptures, Jesus and Karna, the sons of Mary and Kunti, were born this way. Leaving aside these mythological cases, in one animal, the sea-urchin, it has been possible to stimulate unfertilized eggs to divide under the stimulus of certain chemicals. The same is true of the eggs of some fishes and amphibians. In plants also occasional haploid individuals are known to occur in nature and botanists have thought wistfully of producing them artificially (*see* Maheshwari *et al.*, 1958). Dozens of treatments, physical as well as chemical, have been attempted for this purpose including exposure to X-rays and the application of such homely things as onion juice and mustard but without any significant success. We tried to achieve this objective through

injections of a number of chemical substances into the ovaries, but without the desired effect. The activation of the angiosperm egg still remains an enigma.

The technique of growing excised ovaries into fruits and excised ovules into seeds in artificial media may provide a new tool for the solution of this problem. While we have so far succeeded only with fertilized ovaries and ovules we now propose to try the unfertilized ones and expose them in test-tubes to various physical and chemical stimuli. This is much more convenient and feasible than to try to expose a whole plant to any desired stimulus.

Just as modern surgery needs special facilities and it is not possible to carry out a two-hour operation of the brain on a table spread out in any ordinary room, so surgical treatments on the living plant have to be carried out with special precautions. Sterile culture rooms, transfer and storage rooms are required. There should be a positive pressure of air which has been sterilized by passing through a bacterial filter. The instruments and glassware can be sterilized by heat but for the operator and the internal surfaces of the room a short exposure to ultraviolet radiation is less dangerous and more effective. After all this is done, the cultures have to be kept under strictly controlled conditions, failing which the results may not be reproducible. The temperature, humidity and light have all to be controlled, and proper records kept. It should be possible then to vary all these factors, one by one, to study their effect. And there should be a garden and glasshouses to provide a ready source of material. Unfortunately very few laboratories in our country have even these elementary facilities. We work under the crudest conditions. It needs two things to do good work: (*a*) the enthusiasm of the individual and his capacity to inspire others, and (*b*) the support which he receives from the politicians and administrators.

Ladies and gentlemen, the subject is wide, this gathering heterogeneous (I mean no disrespect), and the time limited. I have presented a mere sketch of the problem and of what we have been able to accomplish under obviously difficult conditions. I must close by thanking my former pupils Dr. B. M. Johri (Reader in this Department) and Dr. S. Narayanaswami (now Head of the Botany Department at the Vallabhbhai Vidyapeeth, Anand) and a number of coworkers and research assistants for their help and co-operation. Among these I wish to name a few in particular: Mr. N. S. Ranga Swamy, Dr. R. C. Sachar, Dr. R. N. Chopra, Mr. Manohar Lal, Miss Manju Kapoor and my daughter-in-law Nirmala Maheshwari. Thanks are also due to the Indian Council of Agricultural Research and the Council of Scientific and Industrial Research, for the financial aid and facilities provided by them for the furtherance of this work.

The very day I received the galley proofs of this article, I came across Poddubnaja-Arnoldi's paper (1959) entitled " Study of fertilization and embryogenesis in certain angiosperms using living material " in which she reports having followed the entire development of the

embryos in ovules of *Dendrobium nobile*, *Calanthe veitchii*, *Phalænopsis schilleriana* and *Cypripedium insigne*, reared in artificial media immediately after the first cleavage of the zygote.

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* Recently this plant has been identified as a species of *Zephyranthes*.

EXPLANATION OF PLATES

PLATE III

FIG. 1. *In vivo* growth of ovaries of *Iberis amara* as seen at 1, 3, 6, 9, 12 and 15 days after pollination.

FIG. 2. *Iberis amara*, growth of excised ovaries in culture media. *A*, ovary from flower kept for one week in distilled water. *B-F*, two week old ovaries grown in various media. *B*, sucrose (5%). *C*, sucrose (5%) + minerals. *D*, Nitsch's basic medium+vitamins (NBV). *E*, NBV + IAA (5 p.p.m.). *F*, NBV + IBA (5 p.p.m.).

FIG. 3. *Papaver somniferum*. *A*, two-celled pro-embryo at time of inoculation. *B*, globular embryo and cellular endosperm as seen 9 days after inoculation in Nitsch's medium supplemented with kinetin (0·4 mg./l.) + IAA (5 mg./l.). *C*. seedling formed *in situ* in 23 days.

PLATE IV

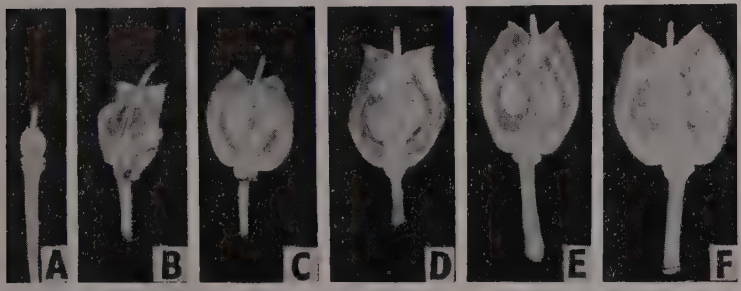
FIG. 4. *In vitro* germination of 14-week old achenes of *Ranunculus sceleratus* in NBV + casein hydrolysate (1,000 p.p.m.). The ovaries were inoculated 3 days after pollination.

FIG. 5. Another similar culture raised on NBV + casein hydrolysate (500 p.p.m.).

FIG. 6. *Citrus microcarpa*, sub-culture of 15-month old psuedobulbils from nucelli raised on White's medium + casein hydrolysate (400 p.p.m.).

FIG. 7. Another culture of the same age showing differentiation of pseudobulbils into seedlings.

1



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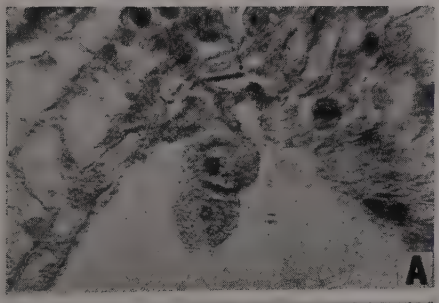
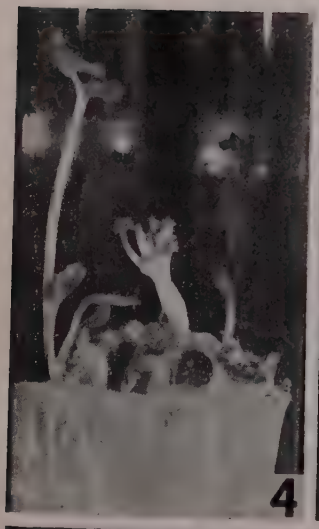
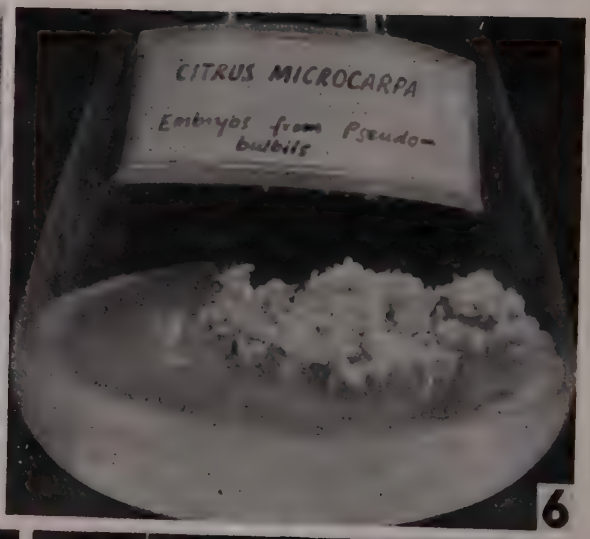
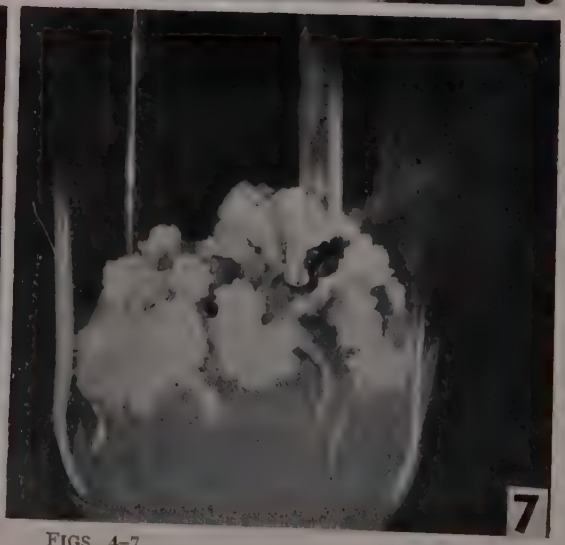


3

P. Maheshwari FIGS. 1–3







P. Maheshwari

FIGS. 4–7

GRASSES OF PAVAGARH

By A. R. Chavan and A. R. Mehta

Botany Department, M. S. University of Baroda

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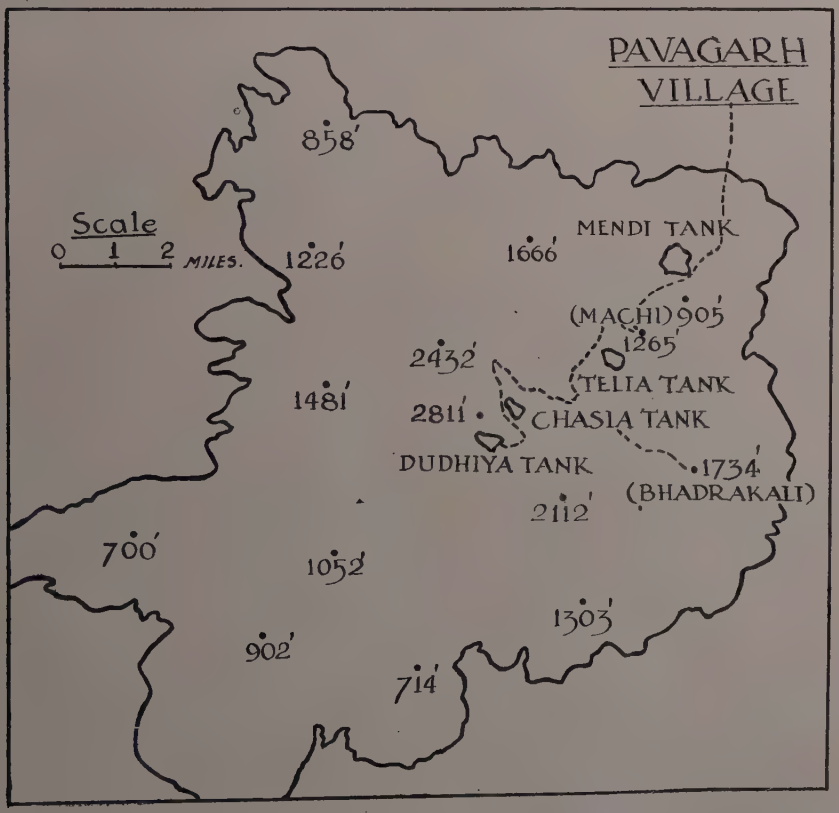
Introduction

Pavagarh Hill is the only hill which stands out rather conspicuously in the plains of Eastern Gujerat, 29 miles by road North-East of Baroda. The hill is three miles in length from North to South and is about as many miles broad.

There is fortification on the hill consisting of strong stone walls, and one has to pass through a series of gates, such as the Attack Gate,



Text-Fig. 1. ' Map of Pavagarh

the Budhya Gate, the Lali Gate, the Sadanshah Gate, the Sulatpur, etc. to reach the top. All the old buildings of historical interest, such as the Khapara Zaveri's Mahal, Makai Kothar, Tankshal and others, are mostly in ruins. There are a few residential quarters at Machi (terraces), one mile five furlongs from the base, at about 1,250 ft. height, consisting of a Government Rest House and a few restaurants. Pavagarh has no importance as a hill station, although there is considerable traffic solely of pilgrims going to temple at the top of the hill.

Pavagarh rocks are formed in the early tertiary by the outpouring larva of the Deccan traps, mostly acidic. The hill consists of a number of terraces formed by successive lava flows, separated at different heights by vertical scarps. The nature of volcanic rock, however, is different at different heights. But in most parts it is 'Basalt' overlain with 'Rhyolite' with occasional layers of broken fragmentary material and volcanic ash beds.

The upper slopes and the top plateau consist mainly of sand-stone and conglomerates with some clay-beds, the lower slopes and valleys are covered with debris brought down from the hills, consisting of boulders and sand mixed with clay beds of varying thickness.

No meteorological records of climatic conditions are maintained at Pavagarh. But the data available at Halol, a village nearby, indicate that November to February are usually cold, the hot months being spread over from March to middle of June, when monsoon sets in. The rainy season ends by September, but sometimes it may run into mid-October.

Previous Work

It is surprising, however, that no systematic attempt has been made to study the flora of this interesting hill.

The earliest attempt is a sketchy report in 1942 by Devkar who made a list of plants of Pavagarh found along the beaten tract.

The first systematic record of the plants of Pavagarh was made by Rev. Father H. Santapau during the day's visit when the Indian Botanical Society organized an excursion to Pavagarh at the time of Forty-third Indian Science Congress at Baroda in 1955. A brief survey of the hill was made about this time by V. G. Phatak and B. B. Joshi and they have published a very useful list of plants they collected.

But both these records are fragmentary as far as the Gramineæ is concerned and it was felt that a detailed study of the grasses of this area should be undertaken. With this aim in view, frequent visits were made to the hill and observations made. The present paper is an outcome of these efforts extending over past several years. It is hoped that it will prove useful because as Sedgwick (1914) has remarked, "in the Cooke's Flora of Bombay Presidency in no point is the treatment of the order Gramineæ more incomplete than in the accounts of the distribution of various species. In a very few cases Cooke has

ventured to describe a species as 'Common' either throughout the Presidency or in a particular area. And among recorded habitats Gujarat figures very rarely".

TAXONOMIC DATA

Subfamily **Panicoideæ**

1. **Chionachne** R.Br.

***Chionachne kænigii* (Spreng.)**

Polytoca barbata Stapf.

Coix barbata Roxb.

Coix kænigii (Spreng.)

Most conspicuous along wayside at about 2,000 feet and above. Dense tussocks in very damp situations. Fls. late September-October.

2. **Ischæmum** Linn.

***I. rugosum* Salisb.**

A rather variable but vigorous annual grass.

Common on marshy ground on the table land at hill top at about 2,600 ft. Fls. late August to October.

Spikelets are usually creamy white.

*** *I. diplopogon* Hook. F.**

An annual found in small patches near river-beds half-way up the hill and on the tableland at the top of the hill.

*** *I. aristatum* Linn.**

***I. ciliare* Retz.**

Mostly tufted perennial found in identical situations as the two above species. Spikelets mostly scarlet.

*** *I. molle* Hook.f.**

Found growing mixed with all the three above species. Spikelets densely villous with soft, silky hairs.

3. **Sehima** Forsk.

***Sehima nervosum* Stapf.**

Andropogon nervosum Rotte.

Ischæmum laxum R.Br.

Common on old walls of ruins. Fls. late August to October.

4. **Thelepogon** Roth.

***T. elegans* Roth. ex Roem. & Schult.**

A rare subgregarious annual on plateau at hill-top. Fls. September-October.

5. **Lophopogon** Hack.

*** *L. tridentatus* Hack.**

A low delicate grass with narrow leaves, preferring wet soils at height, growing mixed with *Ischæmum* sp. by the side of lake at 2,400 ft. beyond "Sulatpur". Fls. Mid-September-October.

6. **Apluda** Linn.

***A. aristata* Linn.**

A. varia Hack. var. *aristata* Hack.

A. mutica Linn. var. *aristata* Pilger.

A densely tufted, polymorphic, annual with many stiff and brittle vegetative shoots, forming large patches under shade and amongst bushes. Fls. late August to October.

7. **Hackelochloa** Kuntz.

***Hackelochloa granularis* O. Kuntz.**

Cenchrus granularis Linn.

Manisuris granularis Linn.

A rare annual found in a few scattered localities, usually shade-loving, near rocks or stones. More frequent beyond Machi (1,250 ft). Fls. September, October.

8. **Saccharum** Linn.

***S. spontaneum* Linn.**

Found on barren lands in valleys and on the margins of dry streams. Fls. September onwards.

9. **Spodiopogon** Trin.

† *S. rhizophorus* (Steud) Pilger.

Andropogon rhizophorus (Steud) Pilger.

Spodiopogon albidus Benth.

A broad leaved and long purple petioled species appears first at about 700 ft. Leaves often become broader with altitude. Common on the upper parts of the hill, locally abundant under shade mixed with Baliospermum axillare Blume at 1,100 ft. Fls. September, October.

10. **Sorghum** Pers.

† ***S. halepense* (Linn.) Pers.**

Holcus halepensis Linn.

Andropogon halepensis Brot.

A tall perennial with stout, creeping rhizomes, frequently locally abundant above 1,600 ft. on muddy soils and near river-beds. Occasionally growing solitary forming large tussocks or sods. Fls. September, October.

11. **Vetiveria** Thouars.

***V. zizanioides* (Linn.) Nash.**

Andropogon squarrosus Hook. f. (non-Linn. f.)

A. muricatus Retz.

Fringing pools and tanks. Fls. September-October.

12. **Chrysopogon** Trin.

***C. montanus* Trin.**

Andropogon monticola Schult.

Stems prominently noded, leaves cordate and auricled, spinuously hairy at margins, sparsely rooting at nodes. On old walls of ruins, also widespread near Makai Kothar on wet soils in which species of *Riccia, Notothylas* and moss grow luxuriantly. Fls. September, October.

13. **Arthraxon** Beauv.

***A. lancifolius* Hochst.**

***A. quartinianus* Nash.**

* ***A. serrulatus* Hochst.**

All the three species of Arthraxon are found in more or less similar situations. All of them are found epiphytic on old walls of the ruins near Machi and beyond, sometimes they arise from crevices of big stones which form steps up the hill, 800 ft. upwards. The walls of some of the Gates are also densely clothed along with *Fimbriaria angusta.*

14. **Capillipedium** Stapf.

* ***C. filiculme* (Hook.f.) Stapf.**

Andropogon filiculmis Hook. f.

Appear at about 1,000 ft. where it is locally widespread in wet, rocky, open situations. Conspicuous on top plateau at about 2,500 ft.

The yellowish green, spreading panicles, borne on slender culms, look beautiful and sway magnificently in breeze.

15. **Dichanthium** Willemet.

***D. annulatum* Stapf.**

Andropogon annulatus Forsk.

Common on plains and foot-hills. Fls. August to October.

***D. caricosum* A. Camus.**

Andropogon caricosus Linn.

Locally widespread on wet soils, preferably under shade, near the Lali Gate and beside the "Cannons", at 1,000 ft. Fls. August to October.

16. **Eremopogon** Stapf.

***E. foveolatus* Stapf.**

Andropogon foveolatus Del.

On waysides, not common, scattered individual near Khapara Zaveri's Mahal, stems forming extensive runners, rooting at nodes, culms 5–10 noded. Fls. late July to October.

17. **Cymbopogon** Spreng.

† ***Cymbopogon schœnanthus* (Linn.) Spreng.**

Andropogon Schœnanthus Linn.

Perennial, coarse, densely tufted grass forming small, isolated clumps over the hill, particularly near top plateau at about 2,400 ft.

***Cymbopogon martini* Stapf.**

Andropogon Martini Roxb.

A. Schœnanthus Linn. var. *Martini* Hook.f.

Rare, usually on slopes.

18. **Heteropogon** Pers.

***H. contortus* (L.) Beauv.**

Andropogon contortus Linn.

Forming small patches locally in rocky places. Fls. Mid-August to October.

* ***H. triticeus* (R.Br.) Stapf. ex. Craib.**

Andropogon triticeus R.Br.

H. insignis Thw.

Locally abundant in muddy marshes at 1,800 ft. and above. Fls. September-October.

19. **Iseilema** Hack.

***I. anthephoroides* Hack.**

Isolated individuals growing on the margins of shallow pools and puddles, sometimes standing right in water. Fls. July to October.

20. **Themeda** Forsk.

***T. triandra* Forsk.**

Anthistiria imberbis Retz.

Themeda imberbis Cooke.

A surface rooting perennial forming large patches after Machi at about 1,400 ft.

***T. quadrivalvis* (Linn.) O. Kuntze.**

Andropogon quadrivalvis Linn.

Themeda ciliata Hack.

Anthistiria ciliata Linn. f.

Rare, on top plateau beyond "Sulatpur".

Usually in the association of *Chionachne kœnigii* (Spreng.).

21. **Pseudanthistiria** Hook.f.

P. hispida Hook.f.

Occasional on sandy wastelands. Fls. August to October.

22. **Digitaria** Hall.

***D. adscendens* (H.B.K.) Henrard.**

Panicum adscendens H.B.K.

Digitaria marginata Link. var. *fimbriata* Stapf.

D. sanguinalis var. *ciliaris* Prain.

Paspalum sanguinalis vars. *ciliare* and *commutatum* Hook.f.

Quite frequent at the base as well as up the hill. In more favourable situations, spikes 2-nate and many in number. Fls. July to October.

*** *D. royleana* Prain.**

Paspalum royleanum Nees ex Thw.

On wet soils, usually in shade mixed with species of *Bonnaya* locally widespread near river-beds up the hill.

23. **Alloteropsis** Presl. emend. Hitchcock.

***A. cimicina* Stapf.**

Axonopous cimicinus Beauv.

Short, fairly common, but scattered, usually on well drained soils at the base of the hill. Tall isolated individuals up the hill. Fls. July to September.

24. **Eriochloa** H.B. & K.

***E. procera* C.E.H.**

E. ramosa O. Kuntze.

E. polystachya H.B. & K.

In marshy places on the plains as well as on lower parts of the hill.

25. **Paspalidium** Stapf.

***P. flavidum* A. Camus.**

Panicum flavidum Retz.

Occasional at the base, under shady situations. More frequent at little altitudes, at about 700 ft. particularly between the Attack Gate and the Budhya Gate, on rich soils. Fls. July to September.

26. **Urochloa** Beauv.

***U. helopus* Stapf.**

Most common after the first few showers, usually in shade along the waysides.

27. **Echinochloa** Beauv.

***E. colona* Link.**

Panicum colonum Linn.

Everywhere except the sandiest soil, in the plains and up the hill. Fls. throughout monsoon.

28. **Oplismenus** Beauv.

***O. burmannii* P. Beauv.**

Panicum burmanni Retz.

Extensively prostrate forming large patches in shade of tall trees, at the foot of the hill. Fls. August to October.

29. **Panicum** Linn.

***P. psilopodium* Trin.**

Occasional in hedges and on sandy uplands among other taller vegetation. Fls. mid-monsoon.

30. **Setaria** Beauv.

***S. glauca* Beauv.**

S. pallidifusca Stapf. ex. Hubbard.

Panicum glaucum Linn.

Occasional on the hill, preferably in partial shade, on moist soils. Fls. August-September.

***S. intermedia* R. & S.**

Panicum intermedium Roth.

Widespread on waste land at the base of the hill, under the canopy of *Wrightia tinctoria* along with species of *Sida*. Fiarly common up the hill. Fls. late July to October.

***S. verticillata* Beauv.**

Frequent on good soil in shady places. Fls. mid-monsoon.

31. **Pennisetum** Pers.

***P. ciliare* Link.**

P. cenchroides Rich.

Cenchrus ciliaris Linn.

On drier parts of the hill. In association with *Cenchrus biflorus* Roxb. Fls. July-August.

32. **Cenchrus** Linn.

***C. biflorus* Roxb.**

C. setigerus Vahl.

On open sandy places, very hardy and flowers right through the dry season.

Subfamily II **Pooideæ**

33. **Arundinella** Raddi.

*** *A. tenella* Nees & Wight.**

A. pumila Steud.

Isolated individuals fairly frequent after 1,200 ft. (beyond Lali Gate), growing from crevices on rocks or clefts of large stones which form steps. Found only during the rains. Fls. late July to October.

34. **Aristida** Linn.

† *A. adscensionis* Linn.

On drier parts of the hill. Fls. August to November.

***A. redacta* Stapf.**

On dry sandy or stony soils.

***A. hystrix* Linn. f.**

An alien, in the same circumstances as *A. adscensionis* Linn.

35. **Nazia** Adans.

***N. racemosa* Kuntze.**

Common in dry, barren, sandy places.

36. **Sporobolus** R.Br.

* ***S. pallidus* Boiss.**

Fairly common on calcareous soils. Fls. late August to October.

***S. coromandelianus* Link.**

A deep rooted and densely tufted, annual common in shady places at the base of the hill.

37. **Eragrostis** Beauv.

***E. ciliaris* Link.**

Uncommon, on clayey soil, usually in hedges.

† ***E. tenella* Beauv. var. *plumosa* Stapf.**

Common on dry water courses or on sandy mud. Locally abundant at about 1,000 ft. near the mouth of the river Vishwamitri and round about Khapra Zaveri Mahal. Fls. July to October.

***E. viscosa* (Retz.) Trin.**

Poa viscosa Retz.

E. tenella var. *viscosa* Stapf.

Common in damp places, more abundant at the base of the hill. Fls. July to September.

***E. unioloides* (Retz.) Nees.**

Poa unioloides Retz.

E. amabilis Wt. & Arn.

Scattered individuals with pink spikes on sandy waysides up the hill, more numerous at about 1,800 ft.

***E. japonica* Trin.**

***E. interrupta* Blat & McC.**

E. interrupta var. *tenuissima* Stapf.

On wet soils, by the side of streams or river-beds, often in water-holes.

***E. minor* Host.**

Common on sandy or muddy soils.

38. **Desmostachya** Stapf.

***D. bipinnata* Stapf.**

Eragrostis cynosuroides Beauv.

On dry sandy soils.

39. **Melanocenchris** Koen.

† ***M. royleana* Nees.**

Gracilea royleana Hochst.

Melanocenchris jacquemontii Jaub. & Spach.

A drawf grass of open sandy places, sometimes of local occurrence and rare. Occasionally on walls of ruins. Fls. September-October.

40. **Cynodon** Rich.

***C. dactylon* (L.) Pers.**

A low creeping perennial grass common from base to the top of the hill, normally flowers almost all the year round.

41. **Chloris** Swartz.

***C. incompleta* Roth.**

Isolated individuals found occasionally.

***C. tenella* Koen.**

Uncommon, growing in protected places, among other taller vegetation.

***C. virgata* Sw.**

Common on dry barren soils by waysides.

42. **Eleusine** Gaertn.

***E. indica* Gaertn.**

Common wherever water runs or accumulates.

***E. coracana* Gaertn.**

Isolated individuals growing by the side of stones, or on sandy soils, as scapes from fields. Fls. August-September.

43. **Dactyloctenium** Willd.

***D. ægyptium* Beauv.**

Eleusine ægyptiaca Desf.

Very common in all places, particularly along the paths.

44. **Tripogon** Roth.

† ***T. sp.***

Rare, small, cæspitose grass found usually in dry places and stony sterile soils, usually along the slopes. Locally abundant in large patches on the flight of steps to the temple at the summit of the hill, frequently on old walls.

45. **Dinebra** Jacq.

***D. retroflexa* Panz.**

D. arabica Jacq.

Occasional with *E. japonica* Trin.

46. **Hygroryza** Nees.

***H. aristata* Nees.**

Forming extensive floating mats in natural ponds at the base as well as half-way up the hill. Fls. September-October.

47. **Elytrophorus** Beauv.

***E. spicatus* (Willd.) Camus.**

E. articulatus Beauv.

Dactylis spicata Willd.

An annual, erect grass found in very dry and sandy places at the base of the hill.

Discussion

It is interesting to note that out of 47 genera collected, 32 (*i.e.*, about $\frac{2}{3}$) belong to the subfamily Panicoideæ, while only 15 are from the subfamily Pooideæ.

Most of the 32 genera of the Panicoideæ are from the two tribes Andropogoneæ, containing 20, and Paniceæ containing 11. Tribe Maydeæ is represented by a single genus *Chionachne*.

Subfamily Pooideæ is represented by the following tribes:—

Arundinelleæ, Stipeæ, Zoysieæ, Sporoboleæ, Oryzeæ, Festuceæ, Eragrosteæ and Chlorideæ. Out of these 8 tribes, the first 6 are represented by a single genus each. But the tribe Chlorideæ alone includes almost as many genera as is the combined total of the genera belonging to the rest of the 7 tribes.

In moist shady places Paniceæ predominates. Though vast majority of the Paniceæ are hygrophilous, an occasional member such as *Cenchrus*

has progressed further in its ecological adaptation and can successfully withstand desert conditions. Genera of the Andropogoneæ, however, exhibit further advanced ecological adaptations, as they occur mostly in dry situations. Nevertheless no genus of Andropogoneæ was found to endure more than semidesert conditions at most. The Andropogoneæ are seldom seen as shade-loving; there are, however, occasional semi-aquatic or marsh forms. For example *Iseilema anthephoroides* is usually found on margins of pools, whereas *Heteropogon triticeus* is found in marshy places.

Thus, in the area under consideration, though Paniceæ and Andropogoneæ show preferences, in point of ecological ranges they often overlap.

The genera from the subfamily Pooideæ are much more prominent as desert grasses than the Panicoideæ; the most xerophytic grasses noted being the species of *Aristida*, *Nazia*, *Gracilea*, *Chloris* and *Tripogon*.

As we climb higher, members of the Andropogoneæ become progressively more prominent and those of the Paniceæ become less and less frequent. The most conspicuous among the former are such genera as *Spodiopogon*, *Sorghum*, *Arthraxon*, *Ischæmum*, *Capillipedium*, *Chrysopogon*, *Manisuris*, *Heteropogon* and *Thelepogon*. The latter include genera *Oplismenus*, *Paspalidium*, *Panicum*, *Alloteroposis* and *Setaria*.

Majority of the Pooideæ seem to be indifferent to increasing height. But several of them show marked preference for greater altitude. *Melanocenchris royleana*, *Digitatia royleana*, *Arundinella tenella*, *Eragrostis unioloides* and *Tripogon* sp. would fall under such category.

The following table gives a statistical summary of the grasses noted:—

TABLE I

Table showing the number of genera and species of grasses at Pavagarh

Subfamily	Tribe	No. of genera	No. of species
Panicoideæ ..	Maydeæ	1	1
	Andropogoneæ	20	29
	Paniceæ	11	14
Pooideæ ..	Arundinelleæ	1	1
	Stipeæ	1	3
	Zoysieæ	1	1
	Sporoboleæ	1	2
	Eragorsteæ	2	7
	Chlorideæ	7	10
	Festuceæ	1	1
	Oryzeæ	1	1
TOTAL ..	11	47	70

Summary

Out of 47 genera collected from Pavagarh Hills, 32 belong to the subfamily Panicoideæ and 15 to Pooideæ. Almost all genera of Panicoideæ belong to the tribes Andropogoneæ and Paniceæ. Pooideæ is, however, represented by as many as 8 tribes, 6 of which are monogenetic.

Ecological observations of the species recorded give certain interesting suggestions. Members of Paniceæ are mostly hygrophilous. Whereas members of Andropogoneæ usually occur in dry places, with occasional members exhibiting overlapping of ecological ranges of the two tribes. Genera of subfamily Pooideæ are, however, mostly xerophilous.

Generic composition of the grass flora also changes with altitude. Out of the two tribes of subfamily Panicoideæ, members of Andropogoneæ become progressively more abundant with increasing elevation, while members of Paniceæ become gradually less frequent. The subfamily Pooideæ, on the other hand, seems to be indifferent to altitude, though certain of its genera show marked preference for greater altitude.

Out of these 69 species noted above, 10 species (marked with * in Taxonomic Data) are not recorded in Gujarat by Blatter and McCann in *The Bombay Grasses*, Cooke in *Flora of Bombay Presidency*, Hooker in *Flora of British India* and Sedwick in *List of Grasses from Ahmedabad and Surat*.

In the Flora of Pavagarh, but for the 7 grasses (marked † in Taxonomic Data) mentioned by Santapau, all the remaining 63 species are recorded for the first time.

Acknowledgements

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RECENT TRENDS IN THE FLORA OF THE BIHAR STATE

By J. G. Srivastava

National Botanic Gardens, Lucknow

(Received for publication on September 24, 1958)

H. H. Haines' *Botany of Bihar and Orissa*, written in 1921–26, was based partly on the records in Hooker's *Flora of British India*, Vols. 1–7 (1872–97) and mainly on his own observations made in the first two decades of the 20th Century. E. J. Woodhouse's collection of plants of Bihar (publicized by Srivastava in 1954) was of a contemporary period. So that it is now at least 40–50 years that these records were made.

Subsequent to Haines' Botany, about two dozen papers have been published on the vegetation and flora of Bihar (Appendix I). The author's intimate personal knowledge of the flora of Bihar, combined with a thorough study of the literature published so far, shows that the flora of Bihar is undergoing changes, both progressive and retrogressive. These changes are dealt with below:—

The Progressive Tendencies in the Flora of Bihar

The flora of Bihar shows the following seven chief types of progressive tendencies:—

1. Plants that were reported in Haines' Botany as being very rare, rare, occasional, or not common, now occur widely, and have also become common (species marked with * in Table I).

2. Plants that were reported in Haines' Botany from just one or two localities, are now to be found in many more places (species marked with † in Table I).

3. Many of the recently introduced weeds, that were noted by Haines, or by Woodhouse, from just one or two localities, are now to be found in a larger part of the state (species marked with ‡ in Table I).

4. Plants that were known in Haines' book only from North Bihar have now spread to South Bihar (species marked with § in Table I).

5. Plants that were known in Haines' Botany only from South Bihar have now spread to North Bihar (species marked with ‖ in Table I).

6. Many cultivated plants have become naturalized and have started multiplying in numbers either by vegetative means or by seeds (species marked with ¶ in Table I).

7. Many new plants have got introduced in the State of Bihar, some from the Uttar Pradesh and Madhya Pradesh, some from Orissa,

some from Bengal and Assam, many from Nepal, a few even from distant lands (species marked with ° in Table I). This category includes the few cases of oversight by Haines of the previous records, as also Woodhouses' record of species that are not included in Haines' Botany.

TABLE I

A list of plants of the Bihar State that indicate a progressive trend in the present-day flora

¶ *Acalypha ciliata* Forsk.
† *A. indica* Linn.
° *Acanthospermum hispidum* DC.
¶ *Adenanthera pavonina* Linn.
° *Æginetia pedunculata* (Roxb.) Wall.
¶ *Ægle marmelos* (Linn.) Correa.
† *Ærua sanguinolenta* (Linn.) Bl.
† *Æschynomene aspere* Linn.
° *Agyneia bacciformis* A. Juss.
† *Ailanthus excelsa* Roxb.
° *Alisma reniforme* Don.
¶ *Alocasia fornicata* Schott.
¶ *Alpinia melaccensis* Rosc.
° *Alternanthera echinata* Sm.
° *A. paronychioides* St. Hill.
† *Alysicarpus hamosus* Edgew.
° *Anaphalis contorta* DC.
° *Anisomeles heyneana* Benth.
¶ *Annona reticulata* Linn.
¶ *Antigonon leptopus* Hook. & Arn.
° *Antirrhinum orontium* Linn.
† *Apluda aristata* Linn.
§ *Apocopis paleacens* (Trin) Hockr.
† *A. vaginatus* Hack.
° *Aponogeton crispum* Thunb.
° *A. natans* (Linn.) Engl.
° *Argostemma sarmentosa* Wall.
° *A. verticillata* Wall.
¶ *Argyreia nervosa* (Burm.f.) Boj.
† *Artemisia caruifolia* Ham.
° *Arthraxon sub-muticus* Nees.
† *Asphodelus tenuifolius* Cavan.
° *Asystasia gangetica* (Linn.) T. Anders.
° *A. macrocarpa* Nees.
|| *Bacopa hamiltoniana* (Benth.) Wettst.
§ *Bauhinia anguina* Roxb.
|| *Biophytum sensitivum* (Linn.) DC.
° *Blumea amplectans* DC.
† *Boswellia serrata* Roxb.
† *Bothriochloa kuntzeana* A. Camus.
° *B. odorata* A. Camus.
¶ *Bryophyllum pinnatum* (Lamk) Oken.
¶ *Buddleja neemda* Buch-Ham.
¶ *Calotropis gigantia* (Linn.) R. Br.
° *Campanula colorata* Wall.
|| *Cannabis sativa* Linn.
† *Capparis sepiaria* Linn.
† *Cassytha filiformis* Linn.
* *Celsia coromandelina* Vahl.
° *Cenchrus ciliaris* Linn.
|| *Centella asiatica* (Linn.) Urban.
° *Centotheca latifolia* (Obs.) Trin.
° *Ceratophyllum demersum* Linn.
° *Ceropegia vincæfolia* Linn.
† *Chenopodium murale* Linn.
† *Chrysanthellum indicum* DC.
° *Chrysopogon gryllus* Trin.
° *Clematis buchanania* DC.
† *Cleome chelidonii* Linn. f.
° *Clerodendron fragrans* (Vent.) R. Br.
† *Cocculus hirsutus* (Linn.) Diels.
† *Cælachne simpliciuscula* (Wt. & Arn.) Munro.
|| *Commelina hasskarlii* Clarke.
° *C. simsoni* C. B. Clarke.
|| *C. nudiflora* Linn.
† *Conyza ambigua* Ait.
† *Corchorus æstuans* Linn.
° *C. tridens* Linn.
* *C. trilocularis* Linn.
° *Coronopus didyma* Linn.
¶ *Corypha umbraculifera* Linn.
* *Crotalaria hirta* Willd.
¶ *C. incana* Linn.
¶ *C. laburnifolia* Linn.
¶ *C. verrucosa* Linn.
° *Croton bonplandianum* Baill.
° *Crypsis schœnoides* (Linn.) Lamk.
¶ *Cryptostegia grandiflora* R. Br.
° *Curculigo finlaysoniana* Wall.
† *C. recurvata* Dryand.
° *Curcuma ferruginea* Roxb.
† *Cuscuta chinensis* Lamk.
° *Cyanotis barbata* Don.
° *Cymbidium aloifolium* Swartz.
° *Cymbopogon cæsius* (Nees.) Stapf.
° *C. pendulous* (Nees.) Watts.
† *C. jwarancusa* Schultz.
† *Cyperus aristatus* Rottb.
° *C. cephalotes* Vahl.
† *C. distans* Linn. f.
† *C. exaltatus* Retz.
° *C. exaltatus* Retz. var *amœna.*
|| *C. flavescens* Linn.
° *C. iria* Linn. var. *paniciformis* Clarke
° *C. kyllinga* Endl.
° *C. polystachyos* Rottb.
° *Cyrtococcum patens* (Linn.) A. Camus.
¶ *Dalbergia sissoo* Roxb.
° *Dendrobium gamblei* K. & P.
° *D. graminifolium* Wight.
° *D. pygmæum* Lindl.

TABLE I—(*Contd.*)

° *D. transparens* Wall.
° *Derris scandens* (Roxb.) Benth.
† *Desmodium gangeticum* DC. var. *ramnagari* Haines.
† *D. parvifolium* DC.
§ *D. triquetrum* (Linn.) DC.
† *Dichanthium caricosum* Haines.
° *Dioscorea tomentosa* Koen. ex. Roxb.
° *Diplacrum caricinum* R. Br.
|| *Distemon indicum* Wedd.
° *Ecbolium linneanum* Kurz.
° *Eichhornia crassipes* Solms.
° *Echinochloa stagnina* (Retz.) Beauv.
* *Enhydra fluctuans* Lour.
° *Eragrostis ciliaris* (Linn.) Link.
† *E. ciliata* Nees.
° *Eriocaulon setaceum* Linn.
† *E. truncatum* Buch-Ham.
° *Eulophia bicarinata* Hook. f.
° *E. ochreata* Lindl.
§ *Euphorbia fusiformis* Buch-Ham.
° *E. granulata* Forsk.
° *E. helioscopia* Linn.
° *E. hypericifolia* Linn. var. *indica.*
† *E. microphylla* Heyne.
° *E. prostrata* Ait.
° *Eupatorium triplinerve* Vahl.
° *Evolvulus nummularius* Linn.
† *Exacum petiolare* Griseb.
° *Ficus foveolata* Wall. var. *foveolata.*
° *F. thwaitsii* Miq.
† *Fimbristylis podocarpa* Nees.
† *F. thomsonii* Boeck.
¶ *Flacourtia jangomas* (Lour) Raeusch.
|| *Flemingia interrupta* Gaud.
† *Fumaria parviflora* Lamk.
† *Geniospermum elongatum* Benth.
° *Gentiana decemfida* Buch-Ham.
¶ *Glycosmis pentaphylla* (Retz.) Correa.
¶ *Gmelina philippinensis* Cham.
† *Gnaphalium purpureum* Linn.
° *Gomphrena celosioides* Mart.
§ *Grewia multiflora* Juss.
° *G. rhamnifolia* Heyne.
* *Gymnosporia montana* Benth.
° *Gynura crepidioides* Benth.
† *Habenaria goodyeroides* Don.
° *H. longicalcarata* A. Rich.
° *H. reniforme* Hook. f.
° *H. stenopetala* Lindl.
° *Heliotropium marifolium* Retz. var. *wallichii.*
° *H. subulatum* Hochst.
° *Herpestis chamædryoides* H. B. & K.
† *Hibiscus lobatus* O. Ktz.
† *H. micranthus* Linn. f.
* *H. panduræformis* Burm.
* *H. pungens* Roxb.
° *H. surattensis* Linn.
|| *H. tetraphyllus* Roxb.
° *Hitchenia glauca* Wall.
|| *Hydrocotyl rotundifolia* Roxb.
° *Hygrophila salicifolia* (Vahl.) Nees.
‡ *Hyptis suaveolens* (Linn.) Poit.
† *Imperata cylindrica* (Linn.) Beauv.
† *Iphigenia indica* Kunth.
¶ *Ipomœa muricata* (Linn.) Jacq.
† *I. nil* (Linn.) Roth.
° *I. pestigridis* L. var. *capitellata* Clarke.
° *Isachne albens* Trin.
° *Ixora parviflora* Vahl. var. *zeylanica.*
§ *Jasminum scandens* Vahl.
° *Jatropha heterophylla* Heyne.
§ *Jussiæa linifolia* Vahl.
† *Justicia betonica* Linn. var. *ramoisissima*
° *Kampferia angustifolia* Rosc.
° *K. rotunda* Linn.
° *Knoxia mollis* W. & A.
|| *Kyllinga cylindrica* Nees.
" *Lagarosiphon alternifolia* (Roxb.) Druce.
° *Lagascea mollis* Cav.
‡ *Lantana camara* Linn. var. *aculeata* Moldenke.
° *L. trifolia* Linn.
° *Lathyrus sphæricus* Retz.
° *Lemna oligorrhiza* Kurz.
° *L. polyrrhiza* Linn.
° *Lecanthus peduncularis* (Wall.) Wedd.
§ *Leonurus sibiricus* Linn.
† *Leptadenia reticulata* W. & A.
† *Leptochloa chinensis* Nees.
† *Leucas clarkei* Hook. f.
° *L. mollissima* Wall.
* *L. procumbens* Desf.
° *L. stricta* Benth.
† *Linaria ramoisissima* Wall.
* *Lindenbergia indica* (Linn.) O.Ktz.
° *L. macrostachya* Benth.
° *Lindernia nummulariæfolia* (Don.) Wettst.
" *Lolium perenne* Linn.
° *L. temulentum* Linn.
§ *Macaranga denticulata* Muell-Arg.
° *Machilus sericea* Bl.
° *Macrosolen pallens* Miq.
° *Malachra capitata* Linn.
° *Malva verticillata* Linn.
° *Malvastrum spicatum* A. Gray.
† *Medicago denticulata* Willd.
† *M. lupulina* Linn.
† *Melilotus indicus* All.
§ *Melothria zehneroides* Haines.
° *Mentha piperata* Linn.
|| *Meriandra benghalensis* Benth.
° *Microstegium monanthum* A. Camus.
¶ *Millingtonia hortensis* Linn.
° *Moghania lineata* (Linn.) O. Ktz.

TABLE I—(*Contd.*)

° *M. macrophylla* (Willd.) O'Ktz. var. *viridis* Mukerjee
° *Mollugo cerviana* Ser.
|| *M. lotoides* (Linn.) O. Ktz.
° *M. nudicaulis* Lamk.
† *M. oppositifolia* Linn.
¶ *Murraya paniculata* (Linn.) Jack.
¶ *M. kœnigii* (Linn.) Spreng.
† *Musa ornata* Roxb.
° *Myriophyllum indicum* Willd.
|| *Najas graminea* Del.
° *Neptunia oleracea* Lour.
‡ *Nicotiana plumbaginifolia* Viv.
° *Nothosærva brachiata* Wt.
† *Oenanthe stolonifera* Wall.
° *Ophiuros megaphyllus* Stapf.
° *Oxalis latifolia* H. B. & K.
§ *Pachystoma senile* Reichb.
|| *Panicum auritum* Presl.
|| *Paspalidium flavidum* Stapf.
° *P. geminatum* (Forsk.) Stapf.
° *Paspalum vaginatum* Sw. (syn. *P. distichum* Linn.)
¶ *Pedilanthus tithymaloides* Poit.
° *Pennisetum orientale* Rich. var. *triflorum* Stapf.
° *Peperomia pellucida* (Linn.) H. B. & K.
† *Pergularia extensa* N.E. Br.
° *Phaius wallichii* Lindl.
° *Phalaris minor* Retz.
* *Phyllanthus maderaspatensis* Linn.
° *Pilea peploides* Hook. & Arn.
° *Pimpinella diversifolia* DC.
° *Pluchea lanceolata* C. B. Clarke
° *Pogonatherum crinitum* Kunth.
° *Pogostemon parviflorus* Benth.
§ *Polygala crotalarioides* Ham.
° *Polygala furcata* Royle.
¶ *Polygonum fagopyrum* Linn.
|| *Polygonum limbatum* Meissn.
§ *P. minus* Huds.
§ *P. stagnium* Ham.
† *Polypogon monspeliensis* Desf.
¶ *Portulaca tuberosa* Roxb.
|| *Potamogeton indicum* Roxb.
† *Pothos scandens* Linn.
|| *Pouzolzia hirta* Hassk.
° *P. indica* Gaud. var. *alienata* Wedd.
° *P. indica* Gaud. var. *angustifolia* Wedd.
|| *P. pentandra* Benn.
° *P. pentandra* Benn. var. *ramoisissima* Wedd.
¶ *Prosopis spicigera* Linn.
° *Pseudoraphis brunoniana* Griff.
¶ *Rauwolfia canescens* Linn.
° *Roscœa alpinia* Royle
|| *Rotala mexicana* Cham. & Schlect.
■ *R. verticillaris* Linn.
¶ *Ruellia cernua* Roxb.
‡ *R. tuberosa* Linn.
¶ *Rumex vesicarius* Linn.
† *Rungia repens* (Linn.) Nees.
|| *Sacciolepis myosuroides* Haines.
† *Salvia plebeja* R. Br.
|| *Sauromatum guttatum* (Wall.) Schott.
† *Scilla indica* Baker.
† *Scirpus articulatus* Linn.
° *S. maritimus* Linn. var. *affinis* Clarke.
° *S. quinquefarius* Ham.
° *Sclerocarpus africanus* Jacq.
° *Sclerostachya fusca* (Roxb.) A.Camus.
° *Sesbania paludosa* Prain.
° *S. uliginosa* Roxb.
° *Seseli indicum* W. & A.
° *Sisymbrium orientale* Linn.
° *Sonchus asper* (Linn.) Vill.
* *Spergula arvensis* Linn.
* *S. pentandra* Linn.
° *Sphenoclea zeylanica* Gaertn.
° *Solanum pubescens* Willd.
° *S. spirale* Roxb.
° *Spiranthes australis* Lindl.
° *Staurogyna glauca* O. Ktz.
§ *Stephania hernandifolia* Walp.
° *Striga densiflora* Benth.
° *Synedrella nodiflora* Gaertn.
¶ *Tabernæmontana coronaria* R. Br.
¶ *Tecoma stans* Linn.
¶ *Tectona grandis* Linn.
† *Telosma pallida* Craib.
° *Tephrosia pauciflora* Grahm.
° *T. tenuis* Wall.
° *Teramnus labialis* (Linn. f.) Spreng. var. *mollis*
° *Thecostele alata* (Roxb.) Per. & Reichb.
° *Themeda imberbis* T. Cooke.
† *Tiliacora acuminata* (Lamk.) Miers.
¶ *Tinospora cordiflora* (Willd.) Miers.
† *Tragia involucrata* Linn.
° *T. involucrata* Linn. var. *angustifolia*
† *Tragus biflorus* Schultz.
° *Trichodesma amplexicaule* Roth.
‡ *Tridax procumbens* Linn.
† *Triumfetta neglecta* W. & A.
° *Tropidium curculigoides* Lindl.
|| *Typhonium trilobatum* (Linn.) Schott.
† *Urochloa panicoides* Beauv.
° *U. setigera* Stapf.
° *Urtica parviflora* Roxb.
§ *Utricularia stellaris* Linn. f.
|| *Verbena officinalis* Linn.
° *Veronica agrestis* Linn.
° *V. anagallis* Linn.
° *Vicia sativa* Linn. var. *angustifolia*
° *V. tetrasperma* Moench.
° *Vicoa cernua* Dalz.

TABLE I—(*Contd.*)

† *Vinca pusilla* Murr.
† *Vitis bracteolata* Wall.
° *V. lanata* Roxb.
¶ *Wissadula periplocifolia* (Linn.) Thw.
° *Wolffia arrhiza* Wimm.
° *Zeuxine nervosa* (Wall. & Lindl.) Hook. f.
° *Zingiber capitatum* Roxb. var. *elatum*.
° *Zizyphus funiculosus* Buch-Ham.

THE RETROGRESSIVE TENDENCIES IN THE FLORA OF BIHAR

The flora of Bihar shows three main types of retrogressive tendencies:—

1. The tendency of some species to remain confined to the place from where they were originally reported. The reason for their being static is that the plant in question, though it somehow got introduced in the locality, has not been able to succeed, due either to unfavourable climate or to excessive competition with the indigenous species, or due to the fact that the climatically suitable area is very small (species marked with * in Table II).

2. The tendency of certain species to remain rare. They were reported as being rare in Haines' Botany, and they are rare even now. The reason apparently is that the plants are of great medicinal importance and, so, were much sought for in the past, and are being sought for even now (species marked with † in Table II).

3. The tendency of certain species mentioned as being common, to become rare now. Some of the obvious causes for this reduction in number are:

(i) Excessive exploitation by man in the past few decades because the plants are medicinal, or are of commercial importance, or are good timber trees, or they possess edible fruits, seeds and tubers, or are of much botanical interest, or are very ornamental (species marked with ‡ in Table II). The very excessive exploitation of certain plants has led to their almost total extinction (species marked with §). in Table II.

(ii) Due to increased demand for food by an ever-increasing population, man has brought about many changes in the area. He has cut away forests, he has drained marshes, he has cultivated paddy and jute on the low-grass lands, he has reclaimed the alkaline lands, and he has done many other such things that the plants of certain areas are becoming reduced in numbers. In the towns, the exotic and native weeds are becoming rare due to the building activities of man, by his clearing away of the waste lands and of the rubbish heaps, by his pulling down of old buildings and of ruins, by his filling up of the depressions and the ditches, and by his other similar activities. His wholesale cutting away of old badly yielding fruit-trees and his cleaning up of the good orchards of all rubbish, has led to a reduction

in the number of parasites, epiphytes and the lichens on the trees (species marked with ‖ in Table II).

(iii) Due to natural causes, such as the wholesale eating of the plant or its propagules by wild and domesticated animals, or due to the plant being pushed out of existence by the fast-spreading exotic, aquatic weed, *Eichhornia crassipes* Solms., or due to the plant being attacked by virulent and persistent parasites, there has been a reduction in number of certain plants (species marked with ¶ in Table II).

Table II

A list of plants of the Bihar State that indicate a retrogressive trend in the present-day flora

‡ *Abutilon polyandrum* (Roxb.) W. & A.
‡ *Acacia arabica* Willd.
‖ *Achyranthes aspera* Linn.
* *A. bidentata* Bl.
‡ *Aeschynomene aspera* Linn.
‡ *Alhagi camelorum* Fisch.
‖ *Ammania* spp.
¶ *Anaphalis araneosa* DC.
‡ *Andrographis paniculata* Nees.
‖ *Anisomeles indica* (Linn.) O. Ktz.
‖ *Argemone mexicana* Linn.
¶ *Argyreia aggregata* (Roxb.) Choisy.
‡ *Aristolochia indica* Linn.
¶ *Artemisia caruifolia* Ham.
‡ *Arundo donax* Linn.
‡ *Bacopa monnieri* (Linn.) Pennell.
‡ *Balanites ægyptiaca* (Linn.) Delile.
‖ *Barringtonia acutangula* Gaertn.
‡ *Bauhinia vahlii* W. & A.
‡ *Begonia picta* Smith.
‡ *Berberis asiatica* Roxb.
‖ *Bergia ammanioides* Roxb.
‖ *Brassica* spp.
† *Butea monosperma* (Lamk.) O. Ktz.
‖ *Cæsulia axillaris* Roxb.
‡ *Calamus garuga* Buch-Ham.
‡ *C. viminalis* Willd.
† *Cardamine hirsuta* Linn. var. *sylvatica*.
‡ *Cardiospermum halicacabum* Linn.
‖ *Cassia occidentalis* Linn.
‖ *C. tora* Linn.
‖ *C. sophera* Linn.
‡ *Centaurium roxburghii* (Don.) Druce.
‖ *Centipeda orbicularis* Lour.
‖ *Chenopodium album* Linn.
† *C. ambrosioides* Linn.
¶ *Cirsium arvense* (Linn.) Scop.
‖ *Chloris inflata* Link.
‖ *Chrozophora rottleri* (Geiss.) A. Juss.
‡ *Cleome monophylla* Linn.
‖ *C. viscosa* Linn.
¶ *Clerodendron phlomoides* Linn. f.
‡ *C. serratum* (Linn.) Moon.
‡ *C. siphonanthus* R. Br.
¶ *C. viscosum* Vent.
‡ *Cochlospermum religiosum* (Linn.) Alston
‖ *Commelina benghalensis* Linn.
‡ *Cordia dichotoma* Forst. f.
‖ *Cotula hemispherica* Wall.
‖ *Crotalaria medicaginea* Lamk.
‖ *C.* spp.
‖ *Cryptolepis buchanani* R. & S.
‡ *Curcuma amada* Roxb.
‡ *C. angustifolia* Roxb.
‡ *C. aromatica* Salisb.
‡ *C. leucorrhiza* Roxb.
‡ *C. zeodaria* Roscoe.
‖ *Cyanotis axillaris* R. & S.
‡ *Cymbopogon jwarancusa* (Jones) Schultz.
‡ *Cyperus tagetum* Roxb.
‡ *Dalbergia sissoo* Roxb.
‡ *Dendrobium bicameratum* Lindl.
‖ *Dendrophthæ falcata* (Linn. f.) Etting.
‖ *Desmodium gangeticum* DC.
¶ *Dioscorea anguina* Roxb.
¶ *D. belophylla* Voight.
¶ *D. pentaphylla* Linn.
‖ *Dopatrium junceum* Ham.
‖ *Drosera burmanni* Vahl.
‖ *Dysophylla* spp.
* *Eleiotis sororia* DC.
‡ *Eranthemum fastigiatum* (Lamk.) O. Ktz.
‖ *Eriocaulon* spp.
‖ *Eriosema chinensis* Vogel.
‡ *Erycibe paniculata* Roxb.
‡ *Erythrina suberosa* Roxb.
‖ *Eulalia cumminghii* (Nees.) A. Camus
‖ *Euphorbia hirta* Linn.
‖ *E. hypericifolia* Linn.
† *Exacum pedunculatum* Linn.
‖ *E. tetragonum* Roxb.
‖ *Ficus benghalensis* Linn.
‡ *F. glomerata* Roxb.

TABLE II—*(Contd.)*

‡ *F. infectoria* Roxb.
‖ *F. religiosa* Linn.
‖ *Fleureya interrupta* Gaud.
‖ *Fœniculum vulgare* Gaertn.
† *Gardenia gummifera* Linn. f.
‡ *Geranium ocellatum* Camb.
‖ *Glossostigma spathulatum* (Hook., Arn.)
‡ *Gmelina arborea* Roxb.
‡ *Grewia rothii* DC.
‡ *Gymnema sylvestre* (Retz.) R. Br.
‖ *Gymnandropsis gynandra* (Linn.) Briq.
‖ *Habenaria constricta* Hook. f.
‡ *H. commelinifolia* Wall.
‡ *Hardwickia binata* Roxb.
‖ *Hemidesmus indicus* R. Br.
§ *Hibiscus abelmoschus* Linn.
‡ *Holostemma annularis* (Roxb.) K. Schum.
‖ *Hygrophila polysperma* T. Anders.
‖ *Ichnocarpus frutescens* R. Br.
‖ *Ipomœa aquatica* Forsk.
‖ *Jussiæa* spp.
‡ *Kalanchœ heterophylla* Prain.
‖ *Kickxia ramoisissima* (Wall.) Janchen.
‡ *Lathyrus aphaca* Linn.
¶ *Launea asplenifolia* DC.
* *Limnophilla heterophylla* Benth.
* *L. racemosa* Benth.
‖ *L.* spp.
‖ *Lindenbergia indica* (Linn.) O. Ktz.
‡ *Litsæa sebifera* Pers.
‡ *Luisia trichorhiza* Bl.
‖ *Mazus japonicus* (Thunb.) O. Ktz.
‖ *Melastoma malabathrica* Linn.
‖ *Melochia corchorifolia* Linn.
¶ *Merrimia chryseides* Hallier. f.
‖ *Microcarpæa muscosa* R. Br.
‖ *Mollugo stricta* Linn.
‡ *Momordica dioica* Roxb.
‖ *Monochoria hastata* Solms.
‖ *M. vaginalis* Presl.
‡ *Morinda tinctoria* Roxb.
‡ *Naravelia zeylanica* DC.
* *Nasturtium palustre* DC.
‖ *Nigella sativa* Linn.
¶ *Nymphæa* spp.
‡ *Ochna pumilla* Buch-Ham.
† *Operculina turpethum* (Linn.) Silva Manso
‖ *Oplismenus burmannii* (Retz.) Beauv.
¶ *Opuntia dillenii* (Ker-Gawl) Haw.
‡ *Oroxylum indicum* (Linn.) Vent.
† *Ougenia dalbergioides* Benth.
‡ *Oxystelma esculentum* (Linn. f.) R. Br.
† *Pæderia fœtida* Linn.
† *Pentapetes phœnicea* Linn.
‡ *Peperomia reflexa* A. Dietr.
‡ *Pergularia dæmia* (Forsk.) Blatter and McCann.
‡ *Phœnix acaulis* Buch-Ham.
‡ *Pholidota imbricata* Lindl.
‡ *Phragmites karka* Trin.
‡ *Phyllanthus niruri* Linn.
‡ *P. urinaria* Linn.
‡ *Piper longum* Linn.
¶ *Plectranthus menthoides* Benth.
‡ *Plumbago zeylanica* Linn.
¶ *Pogostemon plectranthoides* Desf.
‖ *Polygonum* spp.
‡ *Pongamia pinnata* (Linn.) Merrill.
‖ *Portulaca oleracea* Linn.
‖ *P. quadrifida* Linn.
‖ *Pouzolzia* spp.
‖ *Pteris longifolia* Linn.
‡ *Pterocarpus marsupium* Roxb.
† *Pterospermum acerifolium* Willd.
‡ *Puereria tuberosa* (Roxb.) DC.
‡ *Pygeum andersoni* Hook. f.
† *Rauwolfia serpentina* Benth.
¶ *Rivea hypocrateriformis* Choisy.
‖ *Rorippa indica* (Linn.) Hochreut.
‖ *Rosa involucrata* Roxb.
‡ *Rubia cordifolia* Linn.
‖ *Salix tetrasperma* Roxb.
§ *Santalum album* Linn.
* *Saussurea candicans* Clarke
‡ *Scilla indica* Baker.
¶ *Scirpus grossus* Linn. f.
‖ *Scurulla parasitica* Linn.
‖ *Sida* spp.
‡ *Solanum ferox* Linn.
‡ *S. indicum* Linn.
‡ *Sonerilla tenera* Royle.
‡ *Soymida febrifuga* A. Juss.
‖ *Sphæranthus indicus* Linn.
‖ *Sphenoclea zeylanica* Gaertn.
§ *Spilanthes acmella* Linn.
‡ *Spondias mangifera* Willd.
‖ *Stemodia viscosa* Roxb.
‡ *Sterculia colorata* Roxb.
‡ *Streblus asper* Lour.
‖ *Striga euphrasioides* Benth.
‖ *S. lutea* Lour.
§ *Swertia angustifolia* Buch-Ham. var. *affinis*
‡ *Symplocos racemosa* Roxb.
¶ *Tacca pinnatifida* Forst.
‖ *Tephrosia purpurea* Pers.
‡ *Thalictrum foliolosum* DC.
¶ *Thesium unicaule* Haines.
* *Thlapsi arvense* Linn.
‡ *Thysonalæna maxima* Retz.
‡ *Tiliacora acuminata* Miers.
‡ *Trema orientalis* (Linn.) Bl.
‖ *Trianthema monogyna* Linn. f.
‡ *Tribulus terrestris* Linn.
‖ *Tridax procumbens* Linn.
* *Trigonella corniculata* Linn.
‖ *Triumfetta pentandra* A. Rich.

TABLE II—(*Contd.*)

|| *T. bartramia* Linn.
|| *Typha elephantina* Roxb.
|| *Urena lobata* Linn.
‡ *Urginia indica* (Roxb.) Kunth.
|| *Utricularia* spp.
|| *Vanda parviflora* Lindl.
|| *V. tessellata* Hook.
‡ *Ventilago maderaspatana* Gaertn.
‡ *Vernonia anthelmintica* (Linn.) Willd.
¶ *Viola patrinii* DC.
|| *Viscum* spp.
† *Volutarella divaricata* Benth.
|| *Wahlenbergia gracilis* DC.
§ *Wedelia calendulacea* Less.
‡ *Wendlandia tinctoria* DC.
† *Withania somnifera* (Linn.) Dunal.
|| *Xanthium strumarium* Linn.
|| *Zeuxine sulcata* Lindl.
|| *Zizyphus mauritiana* Lamk.

SUMMARY

Due to natural causes and also due to the interference by man, the flora of the State of Bihar is undergoing changes, both progressive–retrogressive. These have been dealt with here in detail. species.

ACKNOWLEDGEMENTS

The author wishes to thank Prof. K. N. Kaul, F.L.S., Director, National Botanic Gardens, Lucknow, for kind encouragement and Sri. R. G. Bharadwaja for checking the nomenclature of the Grass

APPENDIX I

A list of works on the flora and vegetation of the Bihar State, published subsequent to the Haines' Botany.

ARA, JAMAL, 1954. Orchids of Chota Nagpur. *J. Bengal nat. Hist. Soc.* **26**: 177–185.

BHARADWAJA, R. C. 1958. On the grasses of the Parasnath (Bihar). *J. Indian bot. Soc.* **37**: 228–32.

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SRIVASTAVA, J. G. 1954 *a*. Some recently introduced or newly recorded plants from the Patna District. *J. Bombay nat. Hist. Soc.* **52**: 659–60.

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———. 1958. Vegetation of the Hazaribagh District and the Parasnath Hill. *Revised Districct Gazetteers of the Bihar State, Hazaribagh*, Patna.

———. 1958. Vegetation of the Muzaffarpur District. *Ibid., Muzaffarpur*, Patna.

———. 1958. Vegetation of the Singhbhum District. *Ibid., Singhbhum*, Patna.

———. Vegetation of the Patna, Saran and Champaran District (under publication in the *Revised District Gazetteers of Bihar State*).

———. Vegetation of the Purnea District (under publication in the *Revised District Gazetteers of Bihar*), *Purnea*, Patna.

———. Useful Plants of Bihar (under publication in the Botany part of the *State Gazetteer of Bihar*).

—— AND ACHARI, G. Medicinal Plants of Bihar (under publication in the Botany part of the *State Gazetteer of Bihar*).

STUDIES IN THE ORDER PIPERALES

VII. A Contribution to the Study of Morphology of *Saururus cernuus* L.[1, 2]

By Y. S. Murty

School of Plant Morphology, Meerut

(Received for publication on September 27, 1958)

Introduction

Saururus is one of the three genera belonging to the family Saururaceæ, the other two being *Houttuynia* and *Anemopsis*. Both *Houttuynia* and *Anemopsis* are monotypic, whereas *Saururus* has two species. *Saururus cernuus*, commonly known as lizard's tail because of its long and bent inflorescence, is a perennial herb of the swampy forests and shallow ponds having a wide distribution in U.S.A. This species attracted the attention of more than one worker because of its habit and habitat and also being a breeding place for many of the insects having a nuisance value. The first important publication appeared in 1900 by Johnson who was also the foremost in working out the embryology of other members of Piperales. In his publications he described the embryology, germination of the seed, etc., of *Saururus cernuus* and also discussed in 1905 its affinities. Hill (1906), Holm (1926), Rousseau (1927) and Hall (1940) also contributed to the knowledge of the anatomy of the vegetative parts of this species.

Material and Methods

The material was collected from Cornell University, Ithaca, and kindly sent by Dr. K. Subramanyam at my request. Serial transverse and longitudinal sections of the material 8–12 microns thick were cut and stained with crystal violet, erythrosin and safranin and fast green.

Observations

External Morphology.—Creeping and stoloniferous stems in the mud and aerial erect ones bearing the inflorescences have been reported in *Saururus cernuus*. The stoloniferous branches arise from the axils of the scale leaves on the subterranean basal nodes and help in perennation. The leaves are large and simple.

The flowers are bracteate and somewhat sparsely arranged on the long inflorescence which is bent at the tip. The boat-shaped and

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[1] Based on a portion of a Thesis accepted for the Ph.D. degree of the Agra University.

[2] Research contribution No. 21 from the School of Plant Morphology, Meerut College, Meerut.

membranous bract is adnate to the pedicel from which it gets separated only at the top making the flowers appear as if arising from its upper side. Because of this the inflorescence is variously described as a raceme or spike.

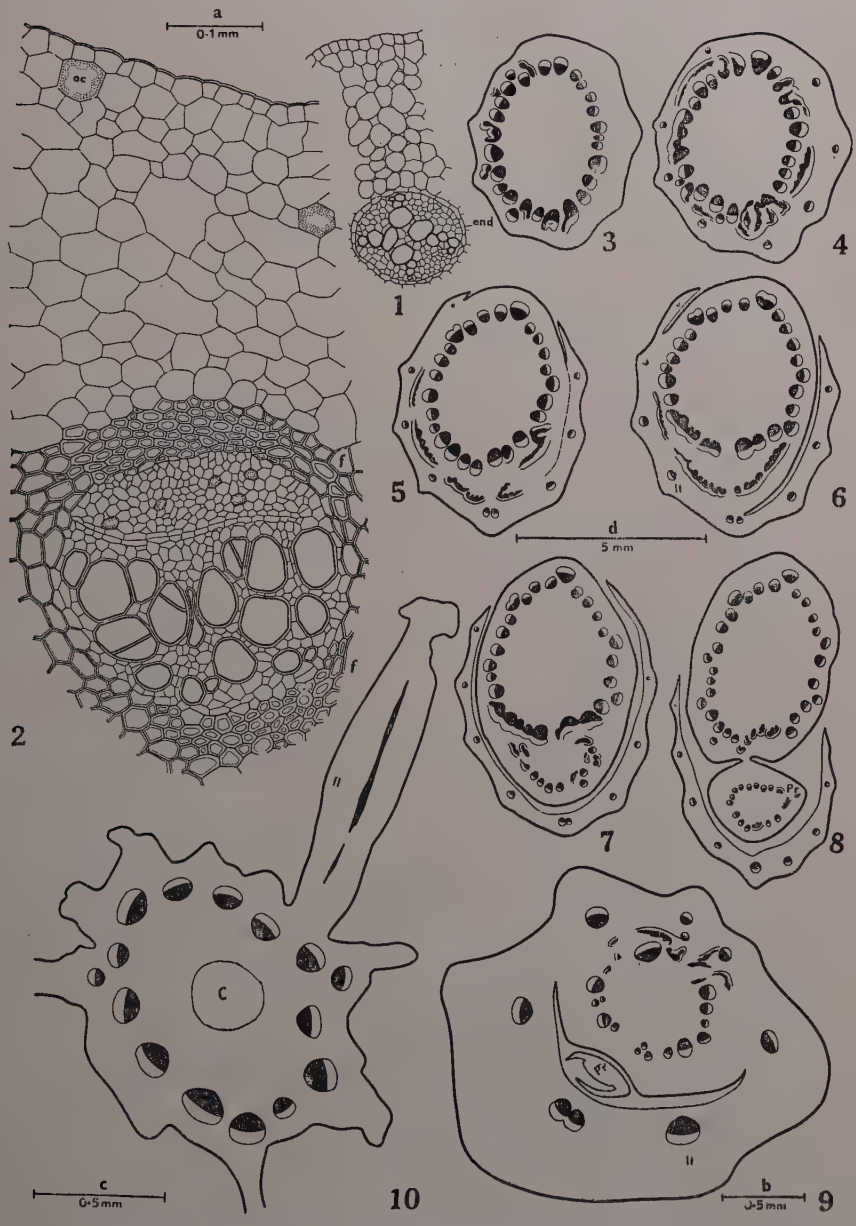
The flowers are naked, and have 6 stamens arising from the receptacle below the gynæceum which consists of 4 free carpels that appear to be somewhat fused at the base to the surface of the torus. Each carpel is partly open on the inner side and so is the curved style.

Vegetative Anatomy.—The roots show a large cortex having intercellular air spaces and a definite endodermis. The young roots possess a tetrarch xylem (Text-Fig. 1) but earlier only triarch and pentarch conditions have been reported by Hall (1940) and Holm (1926) respectively.

The internode is 7–9 furrowed depending on its thickness. The ridges are round and the furrows are very shallow. The epidermal cells are but very slightly thickened, and covered over by a thin layer of cuticle. Generally the cortex consists of many layers of parenchyma (Text-Fig. 2) which shows intercellular spaces in older stems and some collenchyma specially below the ridges. Druses and oil cells also occur here. There are about 20–30 vascular bundles depending upon the age of the stem surrounding a central pith. Most of these are arranged more or less in a ring although some may project out a little (Text-Fig. 3). They are collateral and are capped by about 3–6 layers of fibrous tissue on the outside and 1–4 layers on the inner side (Text-Fig. 2).

The vascular bundles branch and enlarge a little as they approach a node. Some 7–9 bundles diverge out into the cortex almost all round the node as leaf traces that enter the leaf base as it separates off (Text-Fig. 4). It will be noted that the midrib bundle out of these, shows splitting and traverses as a double trace for some distance (Text-Fig. 5). With the departure of the leaf supply, traces for the axillary branch also start diverging out (Text-Figs. 5, 6). These at first form an arc (in cross-section) inner to the midrib region but very soon the arc closes up and forms a cylinder (Text-Figs. 7, 8). From this vascular cylinder one small trace diverges out laterally for the first leaf of the axillary shoot, the prophyll (Text-Fig. 8). Finally the leaf base and its axillary branch separate off. Owing to occasional anastomosing and splitting the number of bundles in the leaf base shows variation from 7–9 (Text-Figs. 8, 9).

The Inflorescence.—The peduncle shows about 8 ridges and grooves. The narrow cortex contains some oil cells. Generally the bundles correspond with ridges and grooves; like those of the internode they are normally oriented (Text-Fig. 10) and capped on both sides by 2–4 layers of fibrous tissue. Within the phloem there are a good number of oil cells. A canal is also found in the centre of the peduncle.



TEXT-FIGS. 1–10. Fig. 1. Part of cross-section of root showing tetrarch condition. Fig. 2. Part of a cross-section of internode showing fibrous caps on both sides of the bundle. Figs. 3–8. Serial transections of a node. Note the leaf traces, doubling of the median leaf bundle and prophyll trace. Fig. 9. Transection of a node showing 7 leaf traces. Fig. 10. Cross-section of inflorescence axis showing floral supply. Note a central canal and ring of bundles. (*C*, Cavity; *end*, endodermis; *f*, fibrous layers; *fl*, flower; *l*, leaf trace; *oc*, oil cell; *Pr*, prophyll.) Scale *a*. Figs. 1 and 2. Scale *b*. Fig. 9. Scale *c*. Fig. 10. Scale *d*. Figs. 3–8.

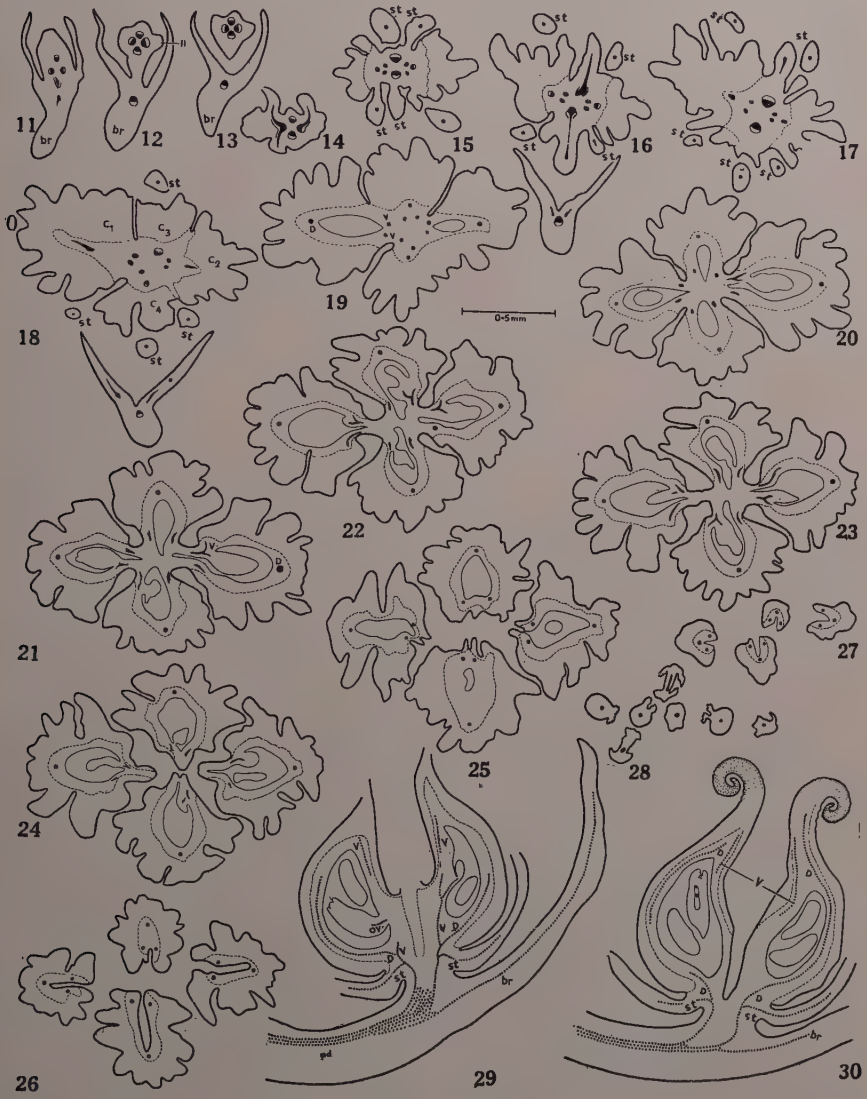
Floral Anatomy.—Corresponding to a flower one bundle passes into the cortex from the main stele of the spike (Text-Fig. 10). After passing through horizontally for some distance in a protuberance it splits up into five branches. The proximal branch supplies the boat-shaped bract while the four distal ones supply the flower(Text-Figs.11,12). The flower is sessile or shortly pedicelled. Very near to its base it appears to be 4–6 lobed with a ring of four collateral bundles (Text-Fig. 13). The two laterally placed bundles give off four traces, two posterior and two anterior (Text-Figs. 14, 15). Two more traces are given off by the two median bundles one on each side (Text-Figs. 16, 17). These six bundles are the staminal traces, of which three are posterior and three anterior. The separation of the filaments follows the same sequence as their traces.

After supplying the staminal traces the remaining portions of the two lateral bundles have in the meantime divided into three each (Text-Figs. 15–18). The median bundles also do the same but at a slightly higher level (Text-Fig. 19). Twelve bundles thus produced constitute the vascular supplies of four carpels that apparently occur in two whorls of two each. The vascular supply of each carpel is differentiated into a median and two laterals. The median bundle of every group passes out with the appearance of a locule and occupies the midrib position in a carpel while the two laterals remain more or less on the inner side and form the ventral bundles of the respective carpel (Text-Figs. 19, 20).

A little higher up each margin comes to bear its own distinct half placenta which is supplied by a ventral bundle. Though both half placentæ of a carpel bear one ovule each they do not possess them at the same level (Text-Figs. 21, 22). It is also interesting to note that the ovules of the four carpels appear in a very regular sequence. For instance, in Text-Fig. 21, it is seen that in the carpel on the right the ovule is borne on the upper half placenta while in the carpel on the left it is borne on the lower half placenta. Ovules in the antero-posterior carpels also follow the same sequence (Text-Fig. 22) and so do the second set of ovules (Text-Figs. 23, 24). Only rarely more than one ovule is borne on a half placenta although Baillon (1874) described more than two. As soon as the carpels get detached from one another, *i.e.*, just above the level of the placenta each carpel appears to be an open structure because the margins are free (Text-Figs. 25, 26).

The ventral bundle after supplying the ovule appears in a cross-section in many cases as if it is passing beyond placenta into the side of the ovary wall (Text-Figs. 22, 23). This is probably due to the shape of the carpel and somewhat oblique sections. The sytles are grooved, the groove being on the adaxial side hence it appears in a cross-section as a conduplicate open structure (Text-Fig. 27). It is slightly curved and bears two papillose stigmatic lobes at the apex (Text-Figs. 29, 30). The dorsal bundle as well as the two ventrals continue in the style and ultimately fuse together in the base of the stigma (Text-Fig. 28).

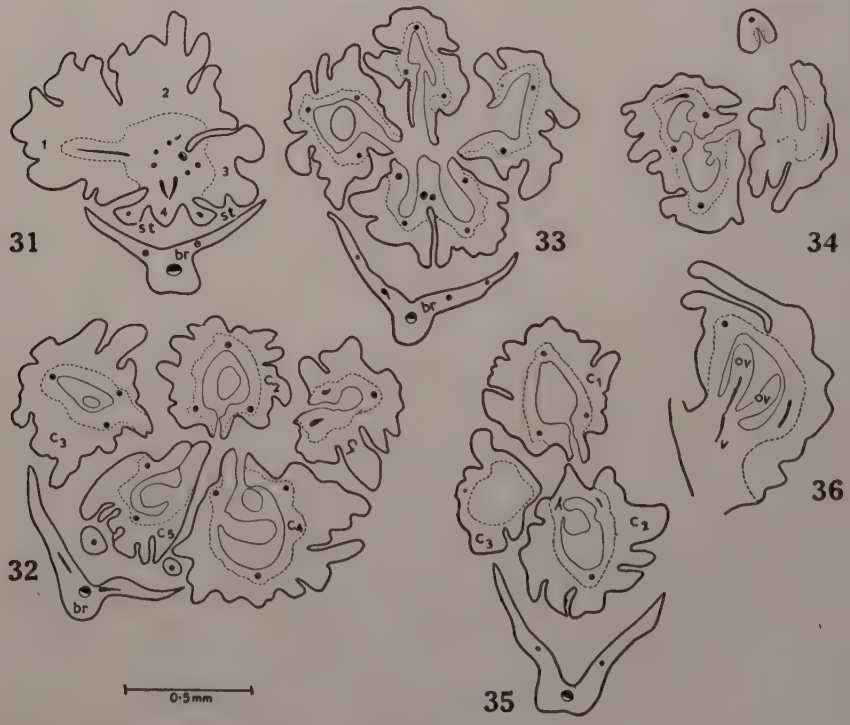
The carpellary wall is irregularly lobed with shallow grooves, and is differentiated into two zones. The outer one consists of many layers



TEXT-FIGS. 11–30. Figs. 11–28. Serial cross-sections of a flower from base upwards. Note the boat-shaped bract, arrangement of six stamens, four carpels and the ovules. The portion up to the dotted line in the figures shows the outer region of the ovary wall with brownish cells. Figs. 29 and 30. Two longitudinal sections of flower. Note the course of vascular bundles supplying bract, stamens and carpels and the curved style. (*Br*, bract; C_1-C_4 carpels 1–4; *D*, carpellary dorsal; *fl*, flower; *ov*, ovule; *St*, stamens; *V*, ventral.)

of cells with brownish walls. This region is thicker in the lobes than in the grooves. Further, it is very much reduced towards the lateral margins, being represented in some cases by the epidermal layer only. The cells of the epidermis are somewhat papillose. Air spaces and oil cells with brownish contents are present. The inner region of the carpellary wall varies in thickness from 3–6 layers, and shows some air spaces but no oil cells. The cell walls are also not brown in colour. The vascular bundles of the carpel pass through this region (Text-Figs. 23, 29 and 30).

Variations.—Some variations have been observed in the arrangement and number of carpels. In a few cases the carpels instead of arising in an opposite decussate manner arise spirally, the last carpel being anterior (Text-Fig. 31). Other minor variations in the order of development are also noted. In some cases five and three carpels have been observed. When there are five the additional one is generally on the anterior side (Text-Fig. 32). In one case of penta-carpellary



Text-Figs. 31–36. Fig. 31. Cross-section of a flower showing spiral arrangements of carpels 1–4. Fig. 32. Cross-section of a flower showing five carpels (C_1-C_5) irregularly arranged. Fig. 33. Cross-section of a flower showing five carpels. Note the two anterior carpels are partly united. Fig. 34. Cross-section of a flower showing only three carpels. Fig. 36. Another flower in cross-sectio with three carpels. Fig. 36. Shows ovular supply arising directly from the ventral bundle situated in the thalamus. (*Br*, Bract; C_1-C_5 carpels 1-5; *or*, ovule; *St*, stamen; *V*. ventral.)

ovary, the two carpels on the anterior side remain fused for some distance and show one common ventral which splits later (Text-Fig. 33). Reduction to apparently three carpels may be due to the fusion of two of the carpels (Text-Fig. 34), or due to the absence of one of the carpels (Text-Fig. 35). In case the third carpel is ill-developed it does not show any ovule. A few cases have been observed where the ovules appear to be arising somewhat basally. The ovule is supplied in such cases by a trace arising from a ventral bundle (Text-Fig. 36). Variation has also been observed in the orientation of the ventral bundle which may be transverse, oblique or inverted.

Discussion and Conclusions

Vegetative Structure.—The leaf receives 7–9 traces which show some branching and fusion in the flattened sheath-like base as well as in the winged petiole. It is interesting to note that the midrib bundle splits up into two in the basal region but the two daughter bundles again fuse together a little higher up. Such a splitting of the midrib bundle has not been described by Rousseau (1927).

Rousseau (1927) considered the thin margins of the leaf base in which two bundles occur, one on each side, as representing the stipules. He regarded the stipules as extending almost to the base of the lamina where they end in two teeth-like projections. Baillon (1874) described the petiole as sheathing at the base and produced into connate stipules. At another place he described stipuliform sheath that envelopes the axillary bud and finally separating off from the petiole on the inner side. In all probability it appears that the small bundles in the extreme margins of the leaf base are stipular traces as was described earlier by Rousseau (1927).

Floral Anatomy.—It has been observed earlier that the flower is supplied by a single bundle which separates from the bract trace. This splits up into four bundles at the base of the receptacle. Of these the two lateral ones give out two stamen traces each and the two median ones, one stamen trace each. All the stamen traces do not diverge out at the same level; the four lateral ones separating somewhat lower than the two median ones. The same sequence is followed in the separation of the filaments. The remaining four stelar bundles reorganize and branch and supply the four carpels with three bundles each—a dorsal and two laterals. This genus differs from *Houttuynia* (Murty, 1956) and *Anemopsis* (Quibell, 1941) in which the stamens are adnate to the ovary wall.

Baillon (1874) described the gynæceum in *Saururus* as consisting of four free carpels, two of which are lateral. He further described that the ventral side is not perfectly closed, and that the parietal placenta is two lipped. Hall (1940) also described the gynæceum as urn-shaped with four distinct carpels. The present observations have confirmed that the carpels are not perfectly closed on the ventral side. They are closed at the base, but are open above the ovule-bearing region. It appears that even at the base the carpellary margins are not fused

together, rather they are all fused with the central receptacular tissue (*cf.* Bailey, Nast and Smith, 1943).

Placentation.—The placentation in *Saururus* has been described differently by various workers. This has been considered parietal (Baillon, 1874); basal (DeCandolle, as reported by Johnson, 1900); lateral (Johnson, 1900); and axile (Van Tieghem, 1918; Lawrence, 1951). The anatomical evidence brought forward here shows that the placentæ are clearly lateral (marginal). It has been seen that the two ventral bundles pass through the two free margins of a carpel. The occasional presence of inverted bundles in the free margins is a further proof to show that the placenta is marginal.

Careful observations reveal that even in those cases where the ovule appears to be basal it is somewhat towards one side and its trace arises from a ventral bundle. Hence such cases should only be regarded as highly reduced and derived.

Summary

Anatomy of the vegetative parts and flower of *Saururus cernuus* has been studied. The roots studied showed only tetrarch condition. The leaf receives 7–9 traces, those in the extreme margins are considered as stipular. Splitting of the midrib bundle in the earlier stages was also observed.

The vascular supply of the bract and the flower has been described. Variations in the number of carpels from 3–5 has been found. The margins of the carpels are free from one another but in the lower region they are fused with the receptacular tissue. The placentæ are regarded as marginal.

Acknowledgements

The author wishes to record his great indebtedness to Prof. V. Puri for his valuable guidance and suggestions. Thanks are also due to Dr. K. Subramanyam for kindly collecting the material.

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ADDITIONAL HOSTS FOR FLOWERING PARASITE

Dendrophthoe falcata (L.f.) Ettingsh (*Loranthus longiflorus* Desr.)

By V. Ravindra Nath and V. L. Narasimha Rao

Agriculture Research Institute, Himayatsagar P.O., Hyderabad-Dn., Andhra Pradesh

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LORANTHUS, a partial stem parasite belonging to the family Loranthaceæ, is an important flowering parasite throughout India. Hooker (1890) gives the number of species in India as 58 which includes *L. longiflorus*, *L. scurrula*, *L. globosus* and *L. cordiflorus*. According to Danser (1929, 1933) the genus *Loranthus* does not occur in India at all and the following genera are admitted in the place of the old genus: *Dendrophthoe*, *Helixanthera*, *Macrosolen*, *Helicanthes*, *Taxillus* and *Tolypanthus*. Santapau (1953) in his Flora of Khandala has followed Danser's system and so *Loranthus longiflorus* Desr. has become *Dendrophthoe falcata* (L.f.) Ettingsh.

A number of authors have given partial lists of the hosts of this plant; generally the lists hitherto published refer to restricted areas. In this paper an attempt is made at bringing together all the scattered data and in addition 17 new hosts are enumerated.

In India *Dendrophthoe falcata* is known to attack both shrubs and trees belonging to various families of dicotyledons and it has been observed in recent times that it is becoming cosmopolitan. Many botanists have attempted to give the host range of *D. falcata* and other species of the old genus *Loranthus*. Among fairly recent workers Cooke (1903–08) reported it on *Mangifera indica* and *Terminalia bellerica*; Fischer (1907) reported it on *Anogeissus latifolia*, *Azadirachta indica* (Syn. *Melia azadirachta*), *Shorea talura*, *Protium caudatum*, *Buchanania latifolia*, *Careya arborea*, *Canthium parviflorum*, *Albizzia amara*, *Acacia leucophlea*, *Eriolæna stocksii* and *Albizzia odoratissima*; Brandis (1907) recorded it on *Madhuca indica* (Syn. *Bassia latifolia*); and Partridge reported it on *Diospyros melanoxylon* from Hyderabad in 1911. They were closely followed by Troup (1921) who noticed on *Shorea robusta* and *Pinus longifolia* in Bihar and Orissa. Later *Eucalyptus rostrata* was added by Patwardhan (1924) from Poona. Soon the most important contribution came from Fischer (1926) who gave a thorough discussion on the subject including a list of 136 new host species which was inclusive of earlier records except those mentioned above. Two more additions, *viz.*, *Psidium guajava* and *Citrus medica* var. *acida* were made by Shrivastava from Allahabad in 1935. From Bombay another new host, *Callistemon linearis*, was published by Ezekiel (1935). From Hyderabad Sayeeduddin and Salam (1935) and Sayeeduddin and Waheed (1936)

reported 8 and 9 host plants respectively of which 2, *viz.*, *Millingtonia hortensis*, *Cordia dichotoma* (Syn. *Cordia myxa*) and 5 *viz.*, *Achras sapota*, *Acacia concinna*, *Calotropis gigantea*, *Murraya kœnigii* and *Eriodendron anfractuosum*, respectively were new additions to the host range. From Bihar, Lacy (1936) reported *D. falcata* on 29 hosts of which 14 only happen to be new records; they are *Aegle marmelos*, *Bauhinia variegata*, *Cassia fistula*, *Codiœum variegatum*, *Grevillea robusta*, *Melia azadirach*, *Premna mucronata*, *Rosa* sp., *Sesbania ægyptiaca*, *Swietenia macrophylla*, *Terminalia catappa*, *Thevetia neriifolia*, *Toona ciliata* (Syn. *Cedrella toona*) and *Morus indica*. *Heritiera minor* was first noticed as a host plant by Mathur (1949) in Madras State. Santapau (1953) while exploring the rich flora of Khandala came across 6 new hosts which are as follows: *Holoptelea integrifolia*, *Casearia graveolens*, *Meyna laxiflora*, *Terminalia crenulata*, *Vitex negundo* and *Woodfordia fruticosa*. From Uttar Pradesh, Singh (1954) published a list of 34 plants which were claimed as new host records of *D. falcata* but only 20 happen to be new hosts. They are *Acacia catechu*, *Bridelia retusa*, *Callistemon lanceolatum*, *Casuarina cunninghamii*, *Duranta plumieri*, *Eleodendron glaucum*, *Eriobotrya japonica*, *Eucalyptus robusta*, *Ficus glomerata*, *Garuga pinnata*, *Gossypium arboreum*, *Grewia asiatica*, *Heritiera fomes*, *Lagerstroemia flosreginæ*, *Mimosa pudica*, *Mimusops elangi*, *Premna latifolia*, *Prosopis juliflora*, *Taxodium distichum* and *Wrightia mollissima*. Again Singh (1956) reported 53 species as new hosts but of them only 46 are new. It appears that the works of Lacy (1936), Fischer (1907, 1926) and Santapau (1953) were overlooked to a great extent. Similarly *Sapindus laurifolius* and *Eugenia jambos* were reported as new hosts by Sayeeduddin and Waheed (1936), whereas Fischer (1926) had already recorded them earlier, the latter as *Jambosa vulgaris* DC. At present the names of both the plants are changed as *Sapindus trifoliatus* Linn. and *Syzygium jambos* (Linn.) Alston. Since Fischer's works both of 1907 and 1926 are not easily available to workers so also the other literature to a lesser extent, a consolidated statement of the up to date host record of *Dendrophthoe falcata* (L.f.) Ettingsh is given in Appendix I. In this appendix older names given by earlier workers have been changed to new ones as far as possible. Whenever such changes are made, older names are given in brackets. These older names are the names under which the particular host was recorded as new by the respective author or authors. Even the spellings have been corrected from the one reported earlier. In all these the authors have widely followed Santapau (1953).

Hyderabad and Secunderabad cities seem to be a favourite ground for *Dendrophthoe falcata*. While observing the flowering periodicity of floricultural plants for the past three years it was observed that plants of *Mangifera indica*, *Azadirachta indica* and *Albizzia lebbek* were affected by the parasite very commonly, many times the attack becoming fatal. When the observations were continued and literature was reviewed it was seen that there are already records of 251 plants as hosts of the parasite and here in the twin cities of Hyderabad and Secunderabad, the following 17 more hosts were noticed for the first time. The new

hosts are as follows. These 17 new additions bring the total number of hosts to 268.

1.	*Acacia arabica* Willd. ..	Mimosaceæ.
2.	*Annona cherimolia* Mill. ..	Annonaceæ.
3.	*Annona reticulata* L. ..	Annonaceæ.
4.	*Bauhinia variegata* L. var. *Candida* Roxb.	Caesalpiniaceæ.
5.	*Cæsalpinia pulcherrima* Sw. ..	Caesalpiniaceæ.
6.	*Citrus reticulata* Blanco ..	Rutaceæ.
7.	*Cryptostegia grandiflora* Br. ..	Asclepiadaceæ.
8.	*Ervatamia divaricata* (L.) Burkill. (Syn. *Taberinamontana coronaria* R. Br.) ..	Apocynaceæ.
9.	*Gossypium barbadens* L. (Perennial Egyptian Cotton) ..	Malvaceæ.
10.	*Guazuma tomentosa* Kunth. ..	Sterculiaceæ
11.	*Jacaranda mimosæfolia* D. Don. ..	Bignoniaceæ
12.	*Lagerstræmia indica* L. ..	Lythraceæ.
13.	*Peltophorum pterocarpum* (DC.) Baker (Copper pod; Ornamental avenue tree)	Caesalpiniaceæ.
14.	*Punica granatum* var. *flore pleno* L. ..	Punicaceæ.
15.	*Santalum album* L. ..	Santalaceæ.
16.	*Sesbania aculeata* Poir. ..	Papilionaceæ.
17.	*Sterculia fœtida* L. ..	Sterculiaceæ.

In Appendix I these new hosts are also included.

Summary

The present paper has consolidated the scattered data available of the host range of *Dendrophthoe falcata* from different parts of India. A list of 251 hosts has been worked out. In addition 17 more new hosts have been reported from the vicinity of Hyderabad and Secunderabad cities, thus bringing the up to date host range of *Dendrophthoe falcata* to 268. The new hosts reported in this paper are as follows: *Acacia arabica*, *Annona cherimolia*, *Annona reticulata*, *Cæsalpinia pulcherrima*, *Bauhinia variegata* var. *candida*, *Citrus reticulata*, *Cryptostegia grandiflora*, *Ervatamia divaricata*, *Gossypium barbadens*, *Guazuma tomentosa*, *Jacaranda mimosaefolia*, *Lagerstræmia indica*, *Peltophorum pterocarpum*, *Punica granatum* var., *flore pleno*, *Santalum album*, *Sesbania aculeata*, and *Sterculia fœtida*.

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APPENDIX I

A complete list of host plants of *Dendrophthoe falcata* recorded in India. Plant names are given in alphabetical order. Abbreviations frequently used in this list are B. (Brandis); C. (Cooke); E. (Ezekiel); F. (Fischer); L. (Lacy); M. (Mathur); P. (Partriage); Pat. (Patwardhan); R. & N. (Ravindra Nath and Narasimha Rao); S. (Santapau); Say. & Sal. (Sayeeduddin and Salam); Say. & Wah. (Sayeeduddin and Waheed); Shr. (Shrivastava); S.B. (Singh Bahadur); and T. (Troup). These stand for the names of workers who made the first record of the host. Names in brackets are the names under which the host record was made by the respective authors, which have become synonyms now. Author epithets against hosts recorded by Fischer (1907); Mathur (1949); Patwardhan (1924); Lacy (1936); Singh Bahadur (1954) and Ezekiel (1935) could not be given as the above-mentioned authors themselves have not indicated the same.

1. *Abrus precatorius* Linn. (F. 1926). 2. *Acacia arabica* Willd. (R. & N., 1958). 3. *Acacia auriculiformis* (F., 1926). 4. *Acacia catechu* (S.B., 1954). 5. *Acacia chundra* (Roxb.) Willd. (F., 1926). (Syn. *Acacia sundra* DC.). 6. *Acacia concinna* DC. (Say. & Wah., 1936). 7. *Acacia farnesiana* Willd. (F., 1926). 8. *Acacia feruginea* DC. (F., 1926). 9. *Acacia latronum* DC. (F., 1926). 10. *Acacia leucophlea* (F., 1907). 11. *Acacia modesta* Wall. (F., 1926). 12. *Acacia pennata* Willd. (F., 1926). 13. *Acacia suma* Buch-Ham. (F., 1926). (Syn. *Acacia suma* Kurtz.) 14. *Acacia tomentosa* Willd. (F., 1926). 15. *Acacia torta* (Roxb.) Craib (F., 1926) (Syn. *Acacia cæsia* Wt. & Arn. non-Willd.). Fischer identified this plant as *A. cæsia* in 1926. In a personal communication Dr. Santapau states that as per Craib this plant does not occur in India at all and that it is mistakenly identified as such by many authors. The correct name is *A. torta*. 16. *Achras sapota* Linn. (Say. & Wah., 1936). 17. *Adina cordifolia* Hook. Fl. (F., 1926). 18. *Aegle marmelos* (L., 1936). 19. *Albizzia amara* (F., 1907). 20. *Albizzia lebbek* Benth. (F., 1926). 21. *Albizzia odoratissima* (F., 1907). 22. *Albizzia procera* Benth. (F., 1926). 23. *Allophyllus serratus* Radlk. (F., 1926) (Syn. *Allophyllus cobbe* Hiern, Fischer gave *A. cobbe* Bl.). 24. *Annona cherimolia* Mill. (R. & N., 1958). 25. *Annona reticulata* L. (R. & N., 1958). 26. *Annona squamosa* L. (F., 1926). 27. *Anogeissus acuminata* Wall. (S.B., 1956). 28. *Anogeissus latifolia* (F., 1907). 29. *Anogeissus pendula* Edgew. (S.B., 1956). 30. *Artocarpus integra* (Thunb.) Merril (F., 1926) (Syn. *Artocarpus integrifolia* L.). 31. *Atalantia missionis* Oliv. (F., 1926). 32. *Azadirachta indica* Juss. (F., 1926) (Syn. *Melia azadirachta*). 33. *Barringtonia acutangula* Gaertn. (F., 1926). 34. *Bassia longifolia* Linn. (F. 1926). 35. *Bauhinia malabarica* Roxb. (F., 1926) (Syn. *Bauhinia malabarica* DC.). 36. *Bauhinia purpurea* Linn. (S.B., 1956). 37. *Bauhinia racemosa* Lam. (F., 1926). 38. *Bauhinia retusa* Ham. (S.B., 1956). 39. *Bauhinia variegata* (L., 1936). 40. *Bauhinia variegata* var. *candida* Roxb. (R. & N., 1958). 41. *Boswellia serrata* Roxb. (F., 1926). 42. *Bridelia retusa* (S.B., 1954). 43. *Buchanania augustifolia* Roxb. (F., 1926). 44. *Buchanania lanzan* Spreng. (F.,

1926). 45. *Buchanania latifolia* (F., 1907). 46. *Cæsalpinia pulcherrima* Sw. (R. & N., 1958). 47. *Callistemon lanceolatum* (S.B., 1954). 48. *Callistemon linearis* (E., 1935). 49. *Calotropis gigantea* R. Br. (Say. & Wah., 1936). 50. *Canthium parviflorum* (F., 1907). 51. *Capparis grandis* Linn. (F., 1926). 52. *Capparis stylosa* Lam. (F., 1926). 53. *Capparis zeylanica* Linn. (F., 1926). 54. *Careya arborea* (F., 1907). 55. *Carissa carandas* Linn. (F., 1926). 56. *Carissa hirsuta* Roth. (F., 1926). 57. *Carissa spinarum* Linn. (F., 1926). 58. *Casearia esculenta* Roxb. (F., 1926). 59. *Casearia graveolens* Dalz. (S., 1953). 60. *Casearia tomentosa* Roxb. (S.B., 1956). 61. *Cassia fistula* (L., 1936). 62. *Cassia montana* Heyne (F., 1926). 63. *Cassia nodosa* Ham. (S.B., 1956). 64. *Cassia siamea* Lam. (F., 1926). 65. *Casuarina cunninghamii* (S.B., 1954). 66. *Casuarina equisetifolia* L. (F., 1926) (Syn. *Casuarina equisetifolia* Forst.). 67. *Celtis australis* Linn. (S.B., 1956). 68. *Chloroxylon swietenia* DC. (F., 1926). 69. *Chrysophyllum olivæforme* Lam. (S.B., 1956). 70. *Citrus aurantium* Linn. (F., 1926). 71. *Citrus medica* var. *acida* (Shr., 1935). 72. *Citrus reticulata* Blanco (R. & N., 1958). 73. *Cocculus pendulus* Diels. (F., 1926). 74. *Codiæum variegatum* (L., 1936). 75. *Combretum ovalifolium* R. (F., 1926) (*Combretum ovalifolium* Walp.). 76. *Commiphora berryi* Engler (F., 1926). 77. *Commiphora caudata* Engler (F., 1926). 78. *Commiphora pubescens* Engler (F., 1926). 79. *Cordia dichotoma* Forst. (Say. & Sal., 1935) [Syn. *Cordia myxa* auct. plur. (Say. & Sal., 1935)] [Syn. *Cordia obliqua* Willd. (S.B., 1956)]. 80. *Cordia evolutior* Gamble (F., 1926). 81. *Cordia vestita* Hk.f. & T. (S.B., 1956). 82. *Cratæva religiosa* Forst. (S.B., 1956). 83. *Cryptostegia grandiflora* Br. (R. & N., 1958). 84. *Dalbergia latifolia* Roxb. (F., 1926). 85. *Dalbergia paniculata* Roxb. (F., 1926). 86. *Dalbergia sisso* Roxb. (F., 1926). 87. *Dalbergia spinosa* Roxb. (F., 1926). 88. *Derris scandens* Benth. (F., 1926). 89. *Desmodium gangeticum* (S.B., 1956). 90. *Desmodium rufescens* DC. (F., 1926). 91. *Dichrostachys cinerea* W. & A. (F., 1926). 92. *Diospyros kaki* Linn. (S.B., 1956). 93. *Diospyros melanoxylon* Roxb. (P., 1911). 94. *Diospyros montana* Roxb. (S.B., 1956). 95. *Diospyros tomentosa* Roxb. (S.B., 1956). 96. *Dolichandrone crispa* Seem. (F., 1926). 97. *Dolichandrone falcata* Seem. (F., 1926). 98. *Duranta plumieri* (S.B., 1954). 99. *Ehretia lævis* Roxb. (F., 1926). 100. *Eleodendron glaucum* (S.B., 1954). 101. *Enterolobium saman* Benth. (F., 1926). 102. *Eriobotrya japonica* (S.B., 1954). 103. *Eriodendron anfractuosum* DC. (Say. & Wah., 1936). 104. *Eriolæna quinquelocularis* W. (F., 1926). 105. *Eriolæna stocksii* (F., 1907). 106. *Ervatamia divaricata* (L.) Burkill (R. & N., 1958) (Syn. *Taberinamontana coronaria* R. Br.). 107. *Eucalyptus robusta* (S.B., 1954). 108. *Eucalyptus rostrata* (Patw., 1924). 109. *Feronia elephantum* Corr. (F., 1926). 110. *Ficus altissima* Bl. (S.B., 1956). 111. *Ficus benghalensis* Linn. (F., 1926). 112. *Ficus gibbosa* var. *parasitica* King (F., 1926). 113. *Ficus glomerata* (S.B., 1954). 114. *Ficus lacor* Buch-Ham. (F., 1926) (Syn. *Ficus infectoria* Roxb.). 115. *Ficus palmata* Forsk. (S.B., 1956). 116. *Ficus religiosa* Linn. (F., 1926). 117. *Ficus retusa* Linn. (F., 1926). 118. *Ficus rumphii* Bl. (S.B., 1956). 119. *Ficus tsiela* Roxb. (F., 1926). 120. *Fla-*

courtia indica Merrill (F., 1926) [Syn. *Flacourtia ramontchi* L'Herit] (F., 1926) and *Flacourtia sepiaria* Roxb. (F., 1926). Fischer (1926) had recorded two hosts as *F. ramontchi* and *F. sepiaria*. Dr. Santapau in a personal communication states that *F. ramontchi*, *F. sepiaria*, *F. latifolia* etc., are all considered by Sleumer, the specialist on the subject, to be synonymous with *F. indica* Merrill and the former names cannot be accepted even as varieties of the species.] 121. *Flacourtia montana* Grah. (F., 1926). 122. *Flacourtia* sp. (F., 1926). 123. *Garcinia xanthochymus* Hk.F. (S.B., 1956). 124. *Garcinia* sp. (F., 1926). 125. *Garuga pinnata* (S.B., 1954). 126. *Glycosmis cochinchinensis* Pierre (F., 1926). 127. *Gmelina arborea* R. (S.B., 1956) (Syn. *Gmelina arborea* Linn.). 128. *Gmelina asiatica* Linn. (F., 1926). 129. *Gossypium arboreum* (S.B., 1954). 130. *Gossypium barbadense* L. (R. & N., 1958). 131. *Grevillea robusta* (L., 1936). 132. *Grewia asiatica* (S.B., 1954). 133. *Grewia disperma* Rottl. (F., 1926). 134. *Grewia elastica* Royle (S.B., 1956). 135. *Grewia oppositifolia* Roxb. (S.B., 1956). 136. *Grewia rotundifolia* Juss. (F., 1926). 137. *Grewia tilæfolia* Vahl. (F., 1926). 138. *Guazuma tomentosa* Kunth. (R. & N., 1958). 139. *Gymnosporia montana* Roxb. (F., 1926). 140. *Gyrocarpus americana* Jacq. (F., 1926). 141. *Hardwickia binata* Roxb. (F., 1926). 142. *Helicteres isora* L. (F., 1926). 143. *Hemicyclia sepiaria* W. & A. (F., 1926). 144. *Heritiera fomes* (S.B., 1954). 145. *Heritiera littoralis* Dry. (F., 1926). 146. *Heritiera minor* (M., 1949). 147. *Holoptelca himalayans* DC. (S.B., 1956). 148. *Holoptelea integrifolia* Planch. (S., 1953). 149. *Hugonia mystax* Linn. (F., 1926). 150. *Hymenodictyon excelsum* Wall. (S.B., 1956). 151. *Ixora arborea* Roxb. (F., 1926) (Syn. *Ixora parviflora* Vahl.). 152. *Jacaranda mimosæfolia* D. Don. (R. & N., 1958). 153. *Jatropha curcas* L. (F., 1926). 154. *Kigelia pinnata* DC. (S.B., 1956). 155. *Kydia calcina* Roxb. (S.B., 1956). 156. *Lagerstræmia flosreginæ* (S.B., 1954) (Syn. *Lagerstræmia speciosa* Pers. Singh, Bahadur has given a record of a plant by name "*Lagerstræmia apeciosa* Pers". Probably he means *Lagerstræmia speciosa* Pers. So it is taken as *L. speciosa* Pers. Over this *L. flosreginæ* is preferred as it is an earlier record as also it is a synonym.) 157. *Lagerstræmia indica* L. (R. & N., 1958). 158. *Lagerstræmia lanceolata* Wall. (F., 1926). 159. *Lagerstræmia parviflora* Roxb. (S.B., 1956). 160. *Lansium* sp. (F., 1926). 161. *Lepisanthes tetraphylla* Radlk. (F., 1926). 162. *Limonia acidissima* Linn. (S.B., 1956). 163. *Limonia alata* W. & A. (F., 1926). 164. *Limonia crenulata* Roxb. (F., 1926). 165. *Litchi chinensis* Sonner (S.B., 1956). 166. *Litsæa chinensis* Lam. (S.B., 1956). 167. *Litsæa polyantha* Juss. (S.B., 1956). 168. *Lumnitzera racemosa* Willd. (F., 1926). 169. *Maba buxifolia* Pers. (F., 1926). 170. *Madhuca indica* Gmel. (B., 1907) (Syn. *Bassia latifolia* Roxb.). 171. *Magnolia grandiflora* L. (S.B., 1956). 172. *Mallotus philippensis* Muell-Arg. (F., 1926). 173. *Mallotus* sp. (F., 1926). 174. *Mangifera indica* L. (C., 1903–08). 175. *Melia azadirach* (L., 1936). 176. *Memecylon umbellatum* Burm. (F., 1926). 177. *Meyna laxiflora* Robyns (S. 1953), 178. *Miliusa velutina* Hk.f. & T. (S.B., 1956). 179. *Millettia tetraptera* Kurz. (S.B., 1956). 180. *Millingtonia hortensis* Linn. (Say. & Sal., 1935).

181. *Mimosa pudica* (S.B., 1954). 182. *Mimusops elangi* (S.B., 1954). 183. *Mimusops hexandra* Roxb. (F., 1926). 184. *Morinda tinctoria* Roxb. (F., 1926). 185. *Moringa oleifera* Lam. (F., 1926). 186. *Morus alba* L. (S.B., 1956). 187. *Morus indica* (L., 1936). 188. *Morus serrata* Roxb. (F., 1926). 189. *Murraya kœnigii* Spreng. (Say. & Wah., 1936). 190. *Murraya paniculata* (Linn). Jack. (S.B., 1956) (Syn. *Murraya exotica* L.). 191. *Mytragyne parviflora* Korth. (F., 1926). 192. *Nieburhia apetala* Dunn. (F., 1926). 193. *Nyctanthes arbortristis* Linn. (S.B., 1956). 194. *Ochna beddomei* Gamble (F., 1926). 195. *Olea cuspidata* Wall. (S.B., 1956). 196. *Peltophorum pterocarpum* (DC.) Baker (R. & N., 1958). 197. *Pinus longifolia* Roxb. (T., 1921). 198. *Pithecolobium dulce* Benth. (F., 1926). 199. *Platanus* sp. (F., 1926). 200. *Plectronia parviflora* Bedd. (F., 1926). 201. *Pongamia pinnata* (Linn.) Pierre (F., 1926) (Syn. *Pongamia glabra* Vent.). 202. *Premna latifolia* (S.B., 1954). 203. *Premna mucronata* (L., 1936). 204. *Prosopis juliflora* (S.B., 1954). 205. *Prosopis spicigera* Linn. (F., 1926). 206. *Protium caudatum* (F., 1907). 207. *Prunus persica* Stokes (F., 1926). 208. *Psidium guajava* (Shr., 1935). 209. *Pterocarpus santalinus* Linn. (F., 1926). 210. *Pterospermum heyneanum* Wall. (F., 1926). 211. *Pterygota alata* (Roxb.) R. Br. (S.B., 1956) (Syn. *Sterculia alata* Roxb.). 212. *Punica granatum* L. (F., 1926). 213. *Punica granatum* var. *flore pleno* L. (R. & N., 1958). 214. *Pyrus communis* Linn. (F., 1926). 215. *Quercus dilatata* Linn. (F., 1926). 216. *Randia dumetorum* Linn. (F., 1926). 217. *Rhizophora* sp. (F., 1926). 218. *Rhodomyrtus tomentosa* W. (F., 1926). 219. *Rosa* sp. (L., 1936). 220. *Salix acmophylla* Boiss. (S.B., 1956). 221. *Salix* sp. (F., 1926). 222. *Salvadora persica* Linn. (F., 1926). 223. *Salmalia malabarica* (DC.) Schot. & Endl. (F., 1926) (Syn. *Bombax malabaricum* DC.). 224. *Santalum album* L. (R. & N., 1958). 225. *Sapindus trifoliatus* Linn. (F., 1926) (Syn. *Sapindus laurifolius* Vahl.). 226. *Sapium sebiferum* Roxb. (S.B., 1956). 227. *Schleichera oleosa* (Lour.) Oken (F., 1926) (Syn. *Schleichera trijuga* Willd.). 228. *Securinega leucopyrus* (Willd.) Muell-Arg. (F., 1926) (Syn. *Fluggea leucopyrus* Willd.). 229. *Sesbania aculeata* Poir (R. & N., 1958). 230. *Sesbania ægyptiaca* var. *bicolor* (L., 1936). 231. *Shorea robusta* Gaertn. (T., 1921). 232. *Shorea talura* (F., 1907). 233. *Sterculia fœtida* L. (R. & N., 1958). 234. *Stereospermum personatum* (Hassk.) Chatterjee (F., 1926) (Syn. *Stereospermum chelonoides* auct. non-nisi partim A. DC.) 235. *Stereospermum suaveolens* DC. (S.B., 1956). 236. *Stereospermum* sp. (F., 1926). 237. *Streblus asper* Lour. (S.B., 1956). 238. *Strychnos potatorum* Linn. (F., 1926). 239. *Swietenia macrophylla* (L., 1936). 240. *Syzygium alternifolium* Walp. (F., 1926). 241. *Syzygium arnottianum* Walp. (F., 1926). 242. *Syzygium cumini* (Linn.) Skeels (F., 1926) (Syn. *Syzygium jambolanum* DC.). 243. *Syzygium jambos* (Linn.) Alston (F., 1926) (Syn. *Jambosa vulgaris* DC.). 244. *Syzygium wightianum* Wall. (F., 1926). 245. *Tamarindus indica* Linn. (F., 1926). 246. *Taxodium distichum* (S.B., 1954). 247. *Tecomella undulata* Seem. (S.B., 1956). 248. *Tectona grandis* Linn. (F., 1926). 249. *Tectona hamiltoniana* Wall. (S.B., 1956). 250. *Terminalia bellerica* R. (C., 1903–08). 251. *Terminalia catappa* (L. 1936). 252. *Ter-*

minalia chebula Retz. (F., 1926). 253. *Terminalia crenulata* Roth. (S., 1953). 254. *Terminalia pallida* Brand. (F., 1926). 255. *Terminalia paniculata* Roth. (F., 1926). 256. *Thespesia populnea* Soland. (F., 1926) (Syn. *Thepesia populnea* Cav.). 257. *Thevetia neriifolia* (L., 1936). 258. *Toddalia asiatica* (Linn.) Lam. (S.B., 1956) (Syn. *Toddalia aculeata* Pers.). 259. *Toona ciliata* Roem. (L., 1936) (Syn. *Cedrella toona*). 260. *Vitex negundo* Linn. (S., 1953). 261. *Woodfordia fruticosa* (Linn.) Kurtz. (S., 1953) [Syn. *Woodfordia floribunda* Salisb. (S. B., 1956)]. 262. *Wrightia mollissima* (S.B., 1954). 263. *Wrightia tinctoria* R.Br. (F., 1926). 264. *Wrightia tomentosa* R.Br. (F., 1926). 265. *Zizyphus glabrata* Heyne (F., 1926). 266. *Zizyphus jujuba* Lam. (F., 1926). 267. *Zizyphus œnoplia* Thuill (F., 1926). 268. *Zizyphus xylopyrus* Willd. (F., 1926).

HEPATICÆ OF BENGAL

I. Sporeling Germination and Taxonomy of *Riccia pimodii* sp. nov. from Burdwan

By P. Kachroo

Botanist, Malaria Research Laboratory, Damodar Valley Corporation, Burdwan

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Introduction

In his Census of Indian Hepaticæ Chopra (1943) recorded 14 species of *Riccia* from India, gave synonymy of *R. robusta* Kashyap, *R. sanguinea* Kashyap and *R. himalayensis* Steph. Recently the following new species have been described from India (and Pakistan): *R. kashyapii* (Kachroo, 1954 *a*); *R. personii*, *R. arnellii* and *R. benghalensis* (Khan, 1957); *R. aravalliensis*, *R. tuberculata* (Pande and Udar, 1957, 1958) and *R. pimodii* Kachroo (present note). Species described as new to India are as under: *R. glauca* L. (Kachroo, 1954 *a*, *b*); *R. sorocarpa* Bisch., *R. huebeneriana* Lindenb., *R. crozalsii* Levier, *R. billardieri* Mont. *et* N. and *R. warnstorfii* Limpr. (Udar, 1956, 1957 *b*), and *R. plana* Taylor (Pande and Udar, 1958). Udar (1957 *a*) recognized *R. gangetica* Ahmad (Ahmad, 1942) as a definite entity, thus differing from Chopra (*loc. cit.*, p. 238) who did not consider it as such. It is evident therefore that *Riccia* is represented in the Indian subcontinent by at least 29 species and possibly more may still be found (Kachroo, in sched.).

Recent studies on morphology of *Riccia* are few. Srinivasan (1940) studied the life-history and cytology of *R. himalayensis* Steph.[1] Kachroo investigated the cytology and life-history of *R. cruciata* Kashyap (Kachroo, 1955 *b*), *R. discolor*, *R. crystallina* and *R. melanospora* (Kachroo, 1955 *a*, *c*). Recently Udar (1957 *c*, *d*, 1958) gave an account of sporeling germination in *R. billardieri*, *R. crystallina* and *R. trichocarpa*; and Udar *et* Chopra (1957) and Chopra *et* Udar (1957) an account of cytology of a few Indian species.

The present note discusses sporeling germination in *Riccia* with particular reference to *R. pimodii* and a *Riccia* with tetrad spores (to be called *R.* "tetrad" in this paper), including a short comment on cytology of the genus and a taxonomic account of *R. pimodii* sp. nov.

Sporeling Germination

Kachroo (1955 *b*, Figs. 36–38) reported a multicellular column at the apex of a germ tube in *R. cruciata*. Due to generalised apical

[1] Udar (1957 *a*) discussed the taxonomic status of *R. himalayensis* Steph. and found that it represented a complex of *R. discolor* and *R. billardieri*. He considers Srinivasan's plant to be *R. billardieri*.

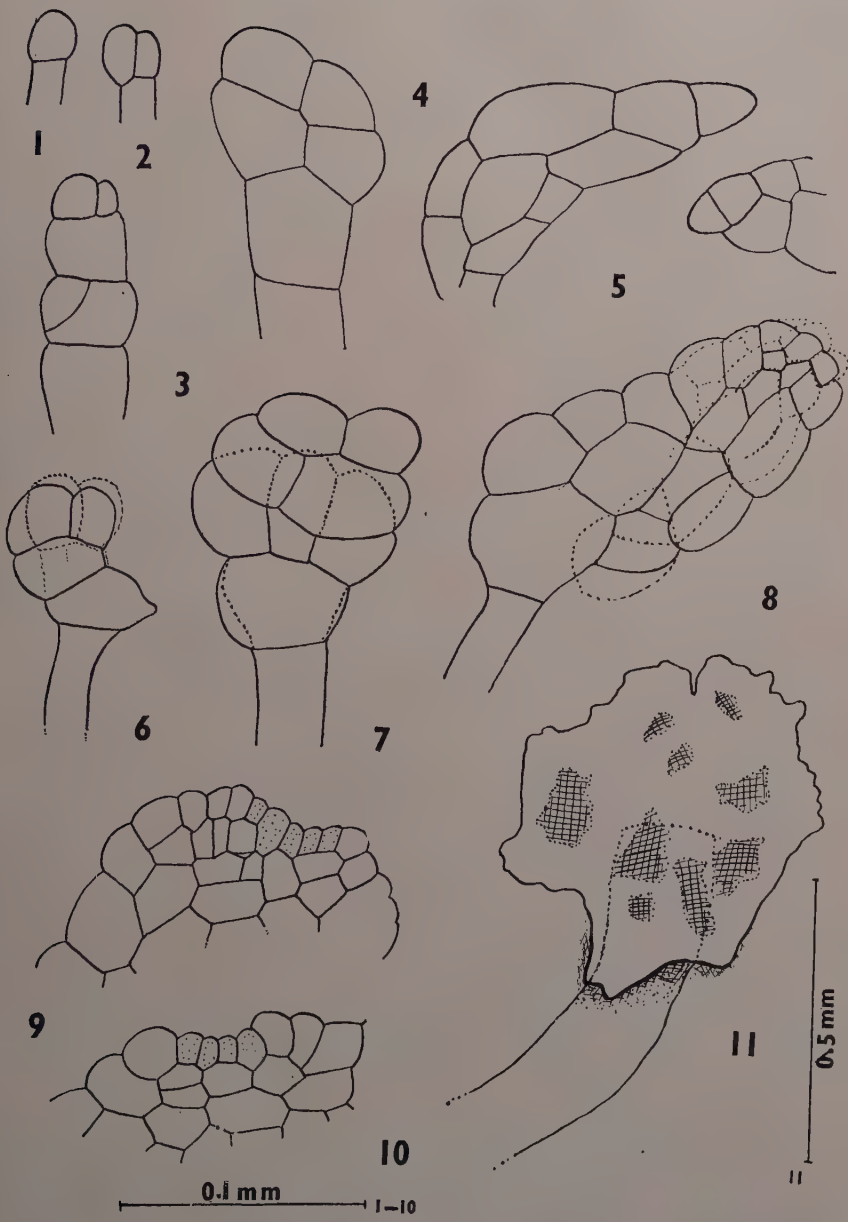
growth this column later fanned out into a gametophyte. Soon an apical meristem was localized and was gradually lodged within the apical notch—the latter formed by the growth of the surrounding tissue. "A single apical cell, however, controls the further growth of the thallus."

Udar (1957 *c*, *d*; 1958) described a few celled germ plate developing an apical cell with two cutting facets and the first rhizoid development similar to that in *Stephensoniella brevipedunculata* Kash. (Mehra and Kachroo, 1952). It may be recalled here that a similar rhizoid development is also reported in Anthocerotales (Mehra and Kachroo, in Press).

In *R. pimodii* Kachroo, *R. plana* Taylor, *R.* "tetrad" and a few other species of *Riccia* (unpublished data) the first stages of germination (Text-Figs. 1–4) up to the formation of a germ plate resemble those of *R. billardieri* (Udar, 1957 *c*) and other Marchantiaceæ (Mehra *et* Kachroo, 1951). However, the present observations (confined mainly to *R. pimodii* and *R.* "tetrad") do not suggest the constant formation of an apical cell with two cutting faces in the earlier stages of development. In a few cases where such an apical cell is indicated (Text-Fig. 4), it has either limited scope and soon vanishes or is an artifact formed due to an oblique position of the vertical wall in the terminal cell of the germ plate. Normally the young disc forms a terminal quadrant (Text-Figs. 5–7) in which walls are laid in horizontal and vertical directions (Text-Fig. 7) resulting in a column. The apical region retains more meristematic activity and flares up into a cellular mass (Text-Fig. 8). in which air-spaces make their appearance, first as irregular cavities (Text-Fig. 11). These cavities differ from those developed on *Stephensoniella* in being lesser to slightly spongy. Towards one side of this cell mass (Text-Figs. 9, 10) the meristematic activity becomes confined and later an apical cell with 4 cutting facets is developed here. [Sporelings grown under excessive moisture and low illumination conditions tend to form long germ tubes and sometimes germ discs which resemble somewhat the *Reboulia*-type (Text-Fig. 12).] Sometimes such sporelings become strap-shaped and assume irregular appearance (Text-Fig. 13). Normal thalli grown under similar conditions become strap-shaped, very long and assume 'algal' appearance (Text-Figs. 14, 15).

It thus appears that some species of *Riccia* resemble *Stephensoniella* in their plan of sporeling germination and few species some other Marchantiaceæ. It may be recalled here that Kashyap (1919) 'derived' *Riccia* on one line through *Stephensoniella* and on the other line through *Aitchisoniella-Targionia*. Nothing is known about sporelings of *Aitchisoniella*, whereas in *Targionia* the germ disc is of the *Reboulia*-type (Kachroo, 1955 *d*)—an umbrella-shaped disc at right angles to the germ tube axis.

The sporeling germination studies also, therefore, suggest that *Riccia* is a polymorphic genus. It is interesting to note here that such a contention has strong cytological support (Kachroo, 1955 *a*). Thus while working on cytology of some West Himalayan riccias Kachroo



TEXT-FIGS. 1–11. Figs. 1–4. Early stages in germination. Fig. 5. Sporeling showing initiation of a quadrant (*b*) in the terminal cell. Figs. 6–8. Stages in development of quadrant and column. Figs. 9–10. Part of sporelings showing apical (localized) meristem. Fig. 11. Germ disc with air cavities.

(*loc. cit.*) found that the chromosome complex falls under three categories, namely: (*a*) species with $n = 9$; 8 ± rod-shaped and one '*m*' chromosome—the dot-shaped one! (*b*) species with $n = 8$; 7 ± rod-shaped and one '*m*' chromosome; (*c*) species with $n = 8$; all ± rod-shaped, '*m*' not represented! Polyploids are known in each category.

In their cytotaxonomic studies on *R. billardieri* and *R. gangetica* Udar and Chopra (1957) seem to have ignored (though erroneously !) the importance (and its presence in some other sps.) of the '*m*' chromosome: which is present both (usually) in $n = 9$ and (sometimes) $n = 8$ species ! Unfortunately they brush it aside as "an error in counting". Importance of '*m*' chromosome in phylogeny of liverworts was briefly discussed by Mehra and Handoo (1953) in their studies on *Anthoceros* and will be dilated upon further elsewhere (Kachroo, in sched.).

Riccia pimodii sp. nov.[2]

Plants green to deep-green in colour, in irregular patches or in regular rosettes, the latter about 35 mm. in diameter. Thallus 2–5 dichotomously branched, up to 20 mm. long, about 3 mm. wide at the widest part; the lobes 2–2·5 mm. wide; the apex nearly flat or indistinctly obtuse; the margin greenish to colourless but apparently pink due to the extended margins of overlapping scales; when dry oblique to somewhat erect, *never reflexed*; median sulcus prominent mostly in the anterior region, not deep, on capsule-bearing shoots up to near base. Ventral scales present, large, pinkish, base greenish, the apex drawn into an 'appendage' reaching and extending slightly beyond the margin of thallus, persistent, about 1 mm. wide, same long. Thallus about 16 cells deep, 1–1·2 mm. thick, about 2 times as broad, more or less roundish beneath, flanks obliquely to nearly transverse, margin acutish. Assimilatory tissue of '*Euriccia*' type, canals narrow, $\frac{1}{3}$ to $\frac{1}{4}$ the thickness of thallus, filaments 4–5 (–6) cells long; the epidermal cells 51–54 × 39–42 μ.

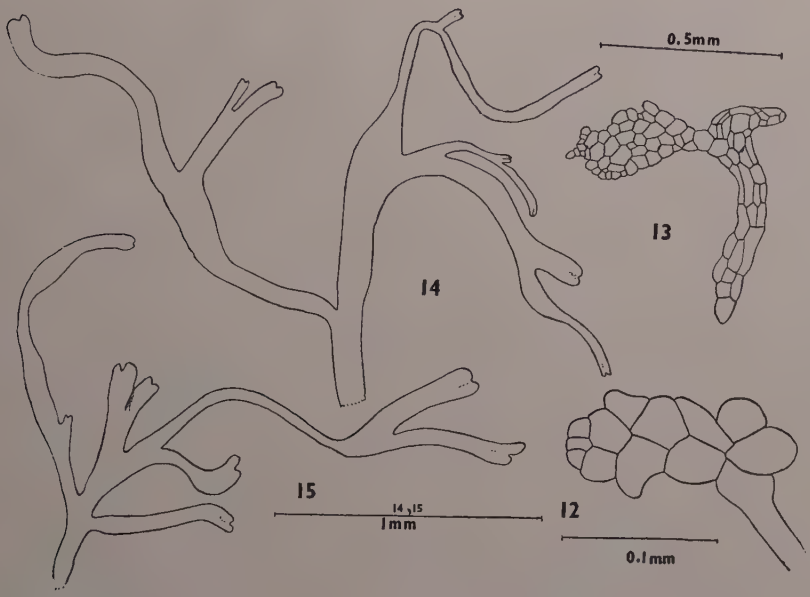
Thalli developing apical tubers (from ventral surface), several per plant, each nodule-like, oval, not subtended by scales, densely covered with rhizoids.

Monœcious ? (antheridium not found). Sporogonia prominent on the dorsal surface, few per thallus, along the median sulcus, never scattered; capsule dehiscing dorsally, spore spherical, opaque, dark brown, 93–105 μ in diameter, triradiate mark usually distinct, weakly

[2] Plantæ viridescentes, in maculis vel rosulis, bis ad quinquies dichotome furcatæ. Lobuli sulco medio ornati, apicibus fere planis. Squamæ ventrales amplæ, persistentes, rosaceæ, appendiculatæ, attingentes margines thalli et paulo ulterius procedentes. Textus assimilatorii eiusdem structuræ ac in Eu-Riccia. Tuberculi nodales apicales normaliter evoluti. Sporogonia efformantur sat raro, numquam dispersa, dorsaliter eminentia; capsulæ dehiscentes dorsaliter. Sporæ sphæricæ, fusce brunneæ, haud translucentes, 93–105 μ diam., infirmiter vel paulisper alatæ; areolæ 12–15 per faciem exteriorem; areolarum anguli elevati in projectiones papillato-filiformes, quæ sunt tenuiores atque elongatæ in facie interiore. Typus lectus ad Burdwan in strato lapideo in templo quodam locali, mixtus Muscis. (Translation through kindness of Dr. H. Santapau, to whom I am grateful.)

(up to 3 μ) to insensibly winged; areolate, 12–15 across the outer face-median ones 9–12 μ wide, walls rather thin, angles elevated into papillate, filiform projections, those on inner areoles usually thinner and elongated about 7 μ tall; those on outer filiform, with acute tips and 6 (–9) μ tall (Text-Figs. 16–25).

Burdwan (West Bengal), on firm moist concerete compound-floor of a local temple, in association with mosses. P. Kachroo, Sept. 14, 1957.



TEXT-FIGS. 12–15. Fig. 12. Sporeling with *Reboulia*-type germ disc. Fig. 13. Same, irregular in appearance. Figs. 14–15. Strap-shaped thalli.

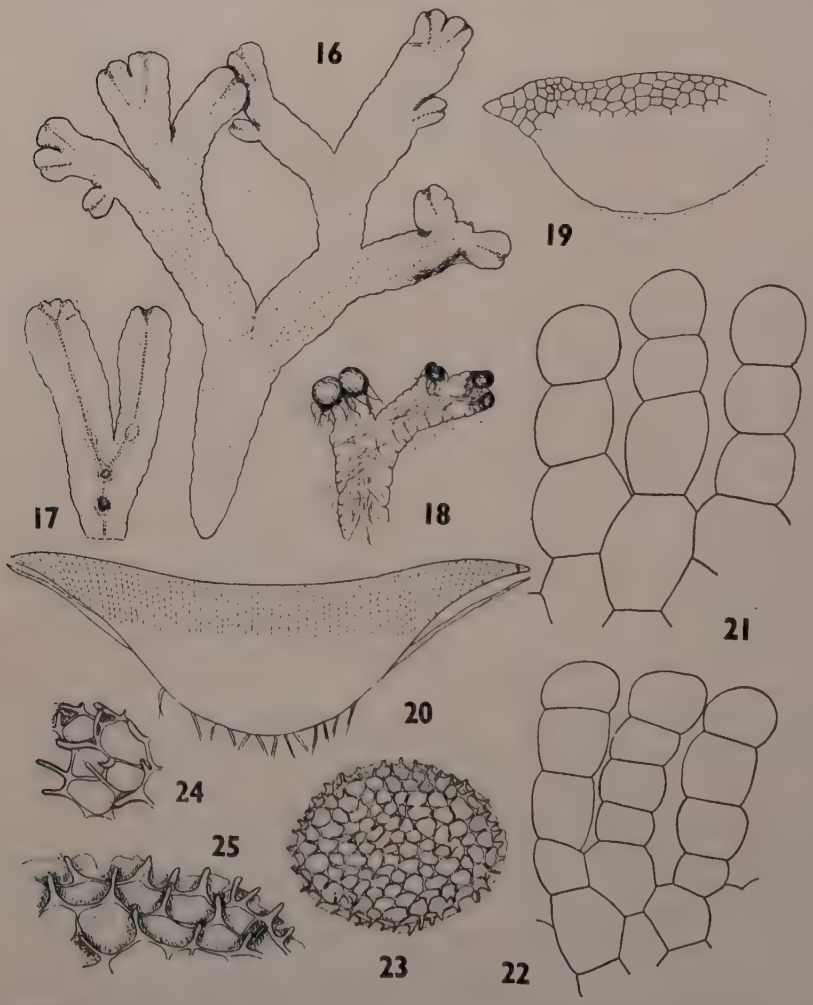
They are very closely fixed to substratum and each apex has the tendency to develop a tuber. Sporogonia and antheridia formation is rare, but tuberous thalli may also bear capsules.

The present species resembles *R. nigrosquamata* Jones in a number of features, namely, (*a*) large, imbricate scales reaching or slightly exceeding the margin of thallus; (*b*) assimilatory tissue of '*Euriccia*'-type; (*c*) spores—the areoles raised up into papillate projections. However, *R. pimodii* has: (*a*) larger thalli; (*b*) apical tubers; (*c*) the apex of lobes nearly flat to obtuse and (*d*) the spore weakly to insensibly winged, with areoles having projections 6–9 μ tall and more prominent. Jones (1957, *f.* 5 *h*, *i*) does not show the capsules dehiscing dorsally nor does he make a mention of it in the text while this is the rule in *R. pimodii*.

In having large imbricate scales reaching the margin of thallus, the areole-angles raised up into projections, *R. pimodii* approaches

R. rhodesiæ Arnell. However, the sharply grooved thallus, smaller spores, larger areoles and much variation in thickness of wings of spores and thallus and the total absence of apical tubers separates the two species.

R. benghalensis Khan (Khan, 1957) differs from *R. pimodii* in having very wide thalli which are 5–6× as broad as high, semilunar scales



TEXT-FIGS. 16–25. Fig. 16. Thallus, ×2½. Fig. 17. Part of thallus with sporogonia ×2½. Fig. 18. Same with apical tubers, ×2½. Fig. 19. Ventral scale, ×20. Fig. 20. *t.s.* thallus (diagrammatic), ×15. Fig. 21. Assimilatory filaments from middle of thallus and along wings (Fig. 22), ×135. Fig. 23. Spore, ×135, Figs. 24–25. Areoles from peripheral and central part of spore, ×285.

hardly extending beyond the margins of thallus, capsules not dehiscing dorsally (?), larger spores with wider areoles and total absence of tubers.

R. pimodii resembles *R. bulbifera* Steph. and *R. billardieri* Mont. *et* N. in the presence of tubers, but differs from the latter in having brown spores (comparatively smaller) with 12–15 areoles across the outer face, capsule dehiscing dorsally and sporogonia formation rare. *R. bulbifera* (Kachroo, 1954 *b*) differs from the present new species in having smaller scales (which are lanceolate), the capsule dehiscing ventrally, larger and darker spores with broad reticulations.

R. pimodii also shares a few features with *R. tuberculata* Pande *et* Udar (1958), namely, (*a*) air-spaces narrow; (*b*) large imbricate scales and (*c*) capsules uniseriate and bulging dorsally. However, the differences are too well marked and further comparisons are unwarranted. [It may be pointed here that Pande and Udar's (*loc. cit.*) Fig. 20 is not convincing so far the 'tuberculate thickenings' are concerned.]

The spores of *R. plano-biconvex* Steph. and *R. subnigella* Herz. (Herzog, 1952), both '*Euriccia*' type, show some resemblances with the spores of *R. pimodii*, but that is all there is to it.

The ensemble of characters described above for this species from Burdwan suggest that a new species is at hand, and this has accordingly been referred to as *R. pimodii* sp. nov. (named after Master Pimod Kachroo who was responsible for its discovery).

Summary

The formation of germ disc in sporelings of *R. pimodii* and a tetrad-spored *Riccia* follow nearly the *Stephensoniella*-plan. Observations on sporelings and cytology lend support to the view that *Riccia* is a polymorphic genus.

R. pimodii with apical tubers is described as a new species.

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THE PEZIZACEAE OF THE MUSSOORIE HILLS—VI

By K. S. Thind and Pritam Singh

Botany Department, Panjab University, Amritsar

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This paper is intended to record more Pezizaceæ from the Mussoorie Hills (5,000–7,500 feet altitude in the North-Western Himalayas) as a part of the study of the fungus flora of that region undertaken by the senior author and his students. The first five contributions (listed under references) describe twenty-seven known species, one known variety, one new variety and three new species. This sixth contribution deals with four known species, all of which are new records for India and two new varieties. The fruit bodies are described from fresh material as well as from that preserved in alcohol-formalin.

The numbers of the species are the serial numbers of the senior author's pezizoid flora of the Mussoorie Hills.

Type collections have been deposited in the Herbarium of the Panjab University. Duplicate material is in the U.S. National Fungus Collections, Beltsville, Maryland.

33. *Lamprospora hæmatostigma* (Hedw.) Boud. var. *gigantea* var. nov.

Apothecia 1–5 mm. diam., gregaria vel congesta, pallide aurantia; asci 202–222 × 12·6–16·2 μ; ascosporæ 12–14·3 μ diam., multiguttulatæ.

Apothecia 1–5 mm. in diameter, mostly 3–5 mm. in diameter, singly, densely gregarious and often crowded together, shallow cupulate to subdiscoid to discoid, regular, or irregular and contorted due to mutual compression, light orange, soft and fleshy, smooth, sessile, attached to the substratum with the periphery free; external surface concolorous or slightly lighter coloured than the hymenium, smooth; excipular cells 7·2–14·4 μ wide, subhyaline with light orange tinge, thin-walled, rhomboid to irregular, pseudoparenchymatous; margin smooth, entire to wavy; hymenium light orange, turning deep orange on drying, smooth, concave to plane.

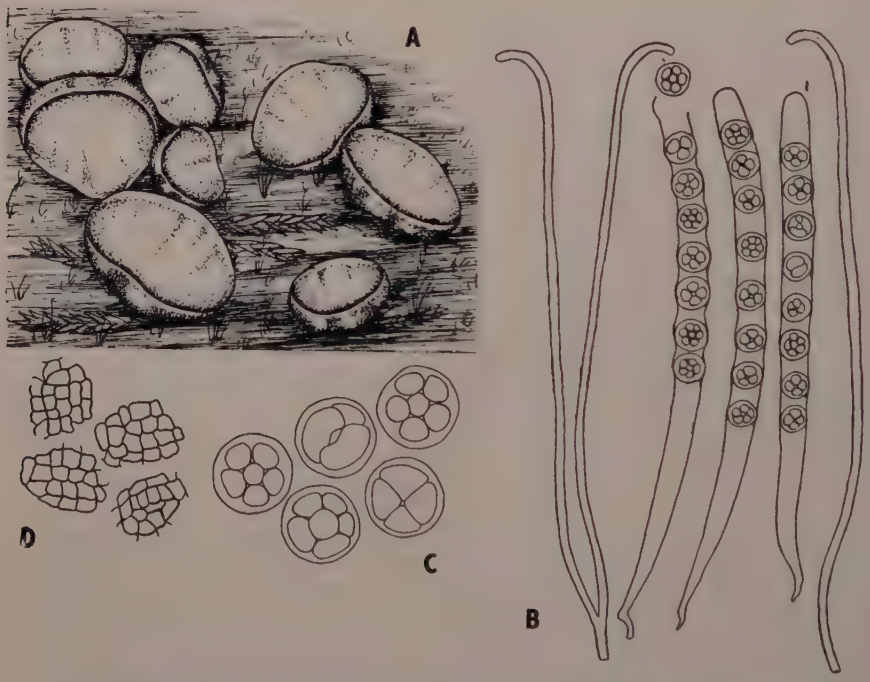
Asci 202–222 × 12·6–16·2 μ, cylindric, apex rounded, tapering below into a stem-like base, bulging out against the spores, do not stain with iodine solution, operculate.

Ascospores 12–14·3 μ in diameter, 8 in number, uniseriate, hyaline, globose, smooth, filled up with large number of granules (or several small guttules) massed together and appearing like the grana of a chloroplast.

Paraphyses 211–250×1·8–2·7 μ, filiform, orange in a mass, subhyaline to ochraceous with an orange tinge individually, non-septate, simple or branched, not enlarged at the top, protruding beyond the asci and strongly curved or hooked at the top.

Text-Fig. 1, A—D.

Collected on humus amid mosses in the Oak forest, Brewery Road, Mussoorie, August 10, 1956, **296**.



TEXT-FIG. 1. *Lamprospora hæmatostigma* (Hedw.) Boud. var. *gigantea* var. nov. A. Apothecia, ×10. B. Asci and Paraphyses, ×400. C. Ascospores, ×950. D. Excipular cells, ×400.

This Mussoorie collection (*n.* 296) is close to *Lamprospora hæmatostigma* (Hedw.) Boud. [= *L. hæmastigma* (Hedw.) Seaver] except that its apothecia are much larger while its ascospores and asci are much smaller as shown below:—

L. hæmatostigma	*Mussoorie fungus*
1. Apothecia reaching up to 1 mm. in diameter	Apothecia 1–5 mm. in diameter (mostly 3–5 mm.)
2. Ascospores reaching a diameter of 20 μ.	Ascospores 12–14·3 μ in diameter.
3. Asci reaching up to 300× 20–23 μ.	Asci 202–222×12·6–16·2 μ.

In view of these important differences, the Mussoorie fungus is regarded here as a new variety of *L. hæmatostigma* (Hedw.) Boud. The varietal name *gigantea* is proposed in view of its very large apothecia.

34. *Pseudopithyella minuscula* (Boud. & Torrend) Seaver, The North Amer. Cup-Fungi (Operculates), p. 152, 1928.

Apothecia 0·6–3 mm. in diameter, 1–4 mm. in height, scattered, very shallow cupulate when young, becoming subdiscoid or discoid at maturity, regular, scarlet or deep orange red, paler coloured on drying, tough, not changing shape on drying, tomentose, stipitate; external surface light orange red, much lighter than the hymenium, delicately and minutely tomentose, even; excipular cells 3·6–14·4 μ wide, subhyaline to very light orange, mostly rectangular, pseudoparenchymatous, thin-walled; margin entire; hymenium deeper coloured, scarlet or deep orange red, smooth, slightly concave to almost plane; stipe up to 2·5 mm. long, slender, variable in length, short, longer when springing from the underside of the substratum, solid, whitish, gradually expanding above into the apothecium, slightly longitudinally ridged.

Asci 230–260 × 9–11·7 μ, cylindric, very long, tapering below into a very long stem-like base, apex round, characteristically marked by two ear-like protuberances (or projections) where the thickened ring passes around near the apex, operculate, operculum circular and 2·7–4·5 μ in diameter.

Ascospores 13·5–16·5 × 7·5–9·7 μ, 8 in number, uniseriate, parallel to oblique, ends overlapping, ochraceous, wall somewhat thick and dark, ellipsoid, ends rounded, smooth, biguttulate, guttules small and distant apart, each lying towards the end.

Paraphyses 1·8–3·6 μ wide at the top, orange red with conspicuous bright red granules, scarlet in mass, filiform, septate, apex slightly and gradually enlarged.

Text-Fig. 2, A—D.

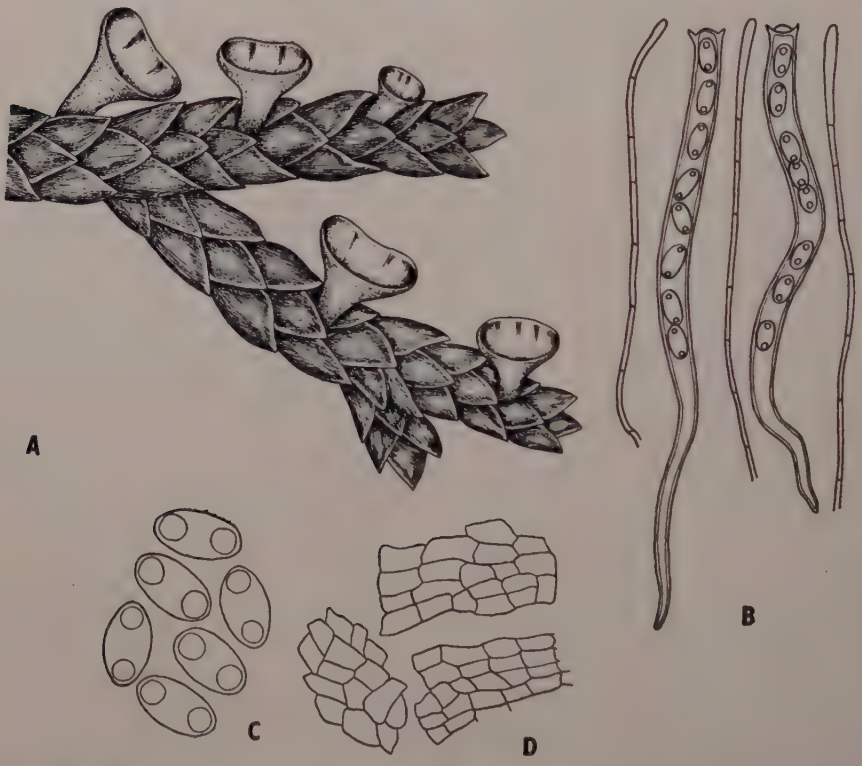
Collected on dead foliage of *Cupressus* sp., The Municipal Garden, Mussoorie, August 7, 1956, **297**. On dead foliage of *Cupressus* sp., The Municipal Garden, Mussoorie, September 7, 1957, **298**. New record in India.

This species is at once recognized by the characteristic external thickened ring formed near the apex of an ascus. The Mussoorie fungus differs from the species in the smaller asci and has been collected only on the dead foliage of *Cupressus* sp. It is rather uncommon in the Mussoorie Hills and has been collected twice from the same locality.

35. *Humaria stercorea* (Pers. ex Fr.) Fckl., Symb. Myc. 321, 1869. [= *Patella stercorea* (Pers.) Weber; Wiggers, Fl. Hols. 106, 1780].

Apothecia 0·8–3·5 mm. in diameter, densely gregarious to congested, shallow cupulate, discoid at maturity, regular, or contorted due to mutual compression, bright orange, fleshy, hairy, sessile, attached

to the substratum except the periphery; external surface orange, sparsely to densely hairy, hairs of two kinds, simple and compound or stellate; simple hairs 260–1185 × 10–23·5 μ, very long, brown to deep brown, mostly at the margin forming a prominent fringe, straight, erect, rigid, bristle-like tapering upward, apex acute, mostly septate, sometimes non-septate, septa up to 25, thick-walled, wall up to 6·3 μ thick, forked (2–6 times) at the base; compound hairs stellate, concolorous with



TEXT-FIG. 2. *Pseudopithyella minuscula* (Boud. and Torrend) Seaver. A. Apothecia, ×20. B. Asci and Paraphyses, ×400. C. Ascospores, ×950. D. Excipular cells, ×400.

the simple hairs, branched at the base into 2–5 rays spreading like a star; rays 147–542 × 9–14·5 μ, mostly at the external surface, very rarely extending above the margin, straight, tapering upward, bristle-like apex acute, thick-walled, wall up to 4·5 μ thick, septate, septa up to 12; excipular cells 9–41·4 μ wide, sub-hyaline to pale ochraceous with a light orange tinge individually, ochraceous to deep ochraceous to light brown in a mass, hexagonal, pseudoparenchymatous, thick-walled; margin hairy, slightly elevated, entire; hymenium bright orange, concolorous to slightly brighter coloured than the external surface, smooth, concave to plane.

Asci 173–195×9–14·4 μ, cylindrical, apex rounded to subtruncate, tapering below into a short stem-like base, do not stain with iodine, operculate.

Ascospores 15–18×8·3–11 μ, 8 in number, uniseriate, parallel to oblique, ends overlapping, ellipsoid, ends rounded, hyaline to sub-hyaline, smooth, uniguttate, gutta large and filling almost whole of the spore cavity.

Paraphyses 188–228×1·8–4·5 μ, up to 7·2 μ wide at the top, orange, clavate, straight, septate, simple, enlarged at the top.

Text-Figs. 3, A—D and 4.

Collected on buffalo dung, The Park, Mussoorie, August 16, 1956, **299.** New record in India.

This species is marked by stellately branched hairs on the coprophilous apothecia and smooth spores. The spore size of this species is very variable as recorded by different authors:—

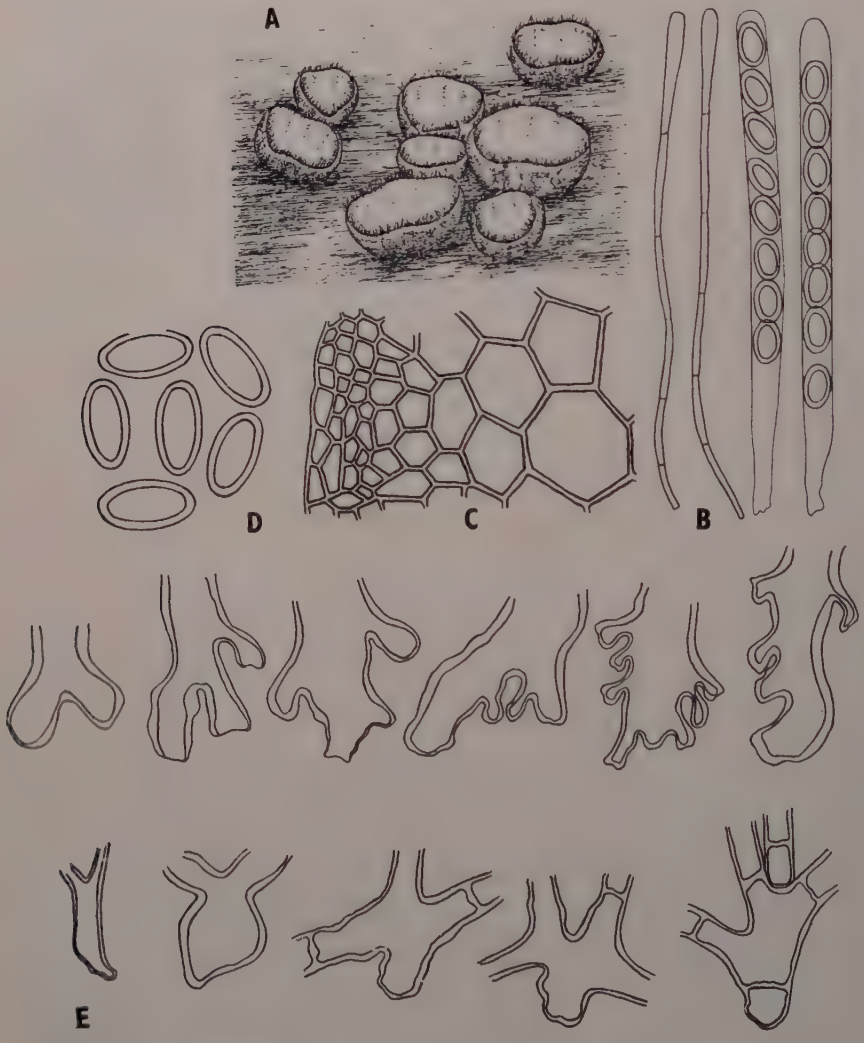
Author	Spore size
Rehm ..	15–20 × 8–10 μ
Saccardo ..	20–22 × 8–9 μ
Le Gal ..	16–21 × 8·5–11 μ mostly 17–19×9–11 μ
Present authors ..	15–18 × 8·3–11 μ

The simple hairs of the Mussoorie collection are narrower and much more septate and rarely non-septate, while its stellate hairs are much longer.

36. *Otidea Smithii* Kanouse, *Pap. Mich. Acad. Sci. Arts & Letters*, **24**: 28, 1939

Apothecia.—1·8–8 cm. in diameter and 2–8 cm. in height, cæspitose or singly, scattered to gregarious, arising from a large solid foot-like base, composed of mycelium (these mycelial hyphæ are 3·6–6·3 μ wide, branched, septate, slender, slightly thick-walled) intermixed with soil, elongate, ear-shaped, split on one side, brown to deep brown to blackish brown, fleshy-tough, on drying becoming leathery and somewhat brittle, furfuraceous, long-stipitate; flesh lighter coloured, unchanging; taste and smell in particular; external surface lighter coloured than the hymenium, brown to deep brown; hypothecium composed of loosely interwoven hyphæ which are sub-hyaline individually and light brown in a mass; excipular cells 9–28·8 μ wide, sub-hyaline to light yellowish brown individually, light to deep brown in a mass, rounded to polygonal, pseudoparenchymatous, very slightly thick-walled, at the surface grouped into irregular and loosely arranged small rows of cells (up to

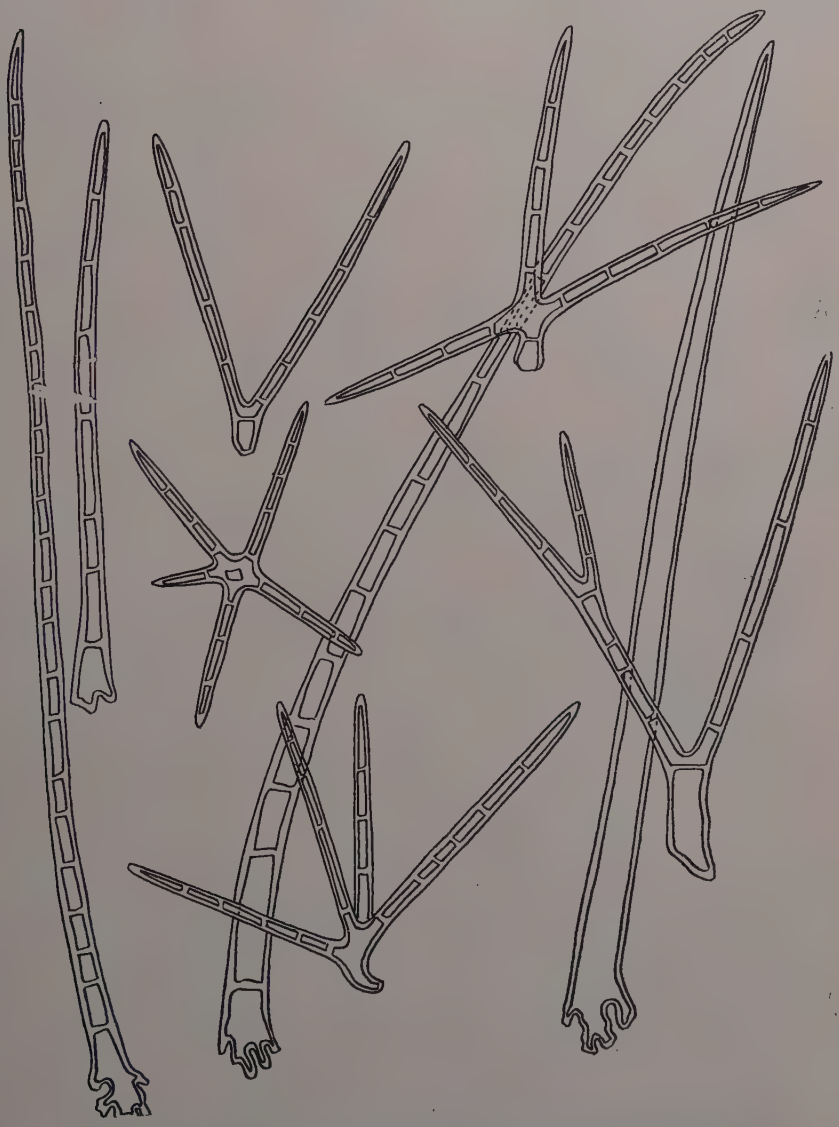
6 cells), surface cells of these rows prominently roughened by small granules golden brown in colour; margin entire, inturned in young specimens; hymenium deeper coloured, deep brown to blackish brown to almost black, smooth; stipe 1·5–3·5 cm. × 6 mm.–1·5 cm., long, cylindrical, expanding above abruptly into the apothecium, densely tomentose, concolorous with the external surface, even, hollow; tomentose hairs 3·2–6·3 μ wide, delicate hyaline, flexuous, hypha-like, septate, branched, apex rounded, smooth to slightly roughened.



TEXT-FIG. 3. *Humaria stercorea* (Pers. ex Fr.) Fckl. A. Apothecia, ×10. B. Asci and Paraphyses, ×400. C. Excipular cells, ×400. D. Ascospores, ×950. E. Bases of hairs, ×400.

Asci 122–155×5·4–9 μ, cylindric-clavate, apex rounded, tapering below into a long stem-like base, not turning blue with iodine, operculate.

Ascospores 10·5–12×5·2–7·5 μ, 8 in number, uniseriate, parallel to oblique, ends often overlapping, hyaline to sub-hyaline (or pale ochra-



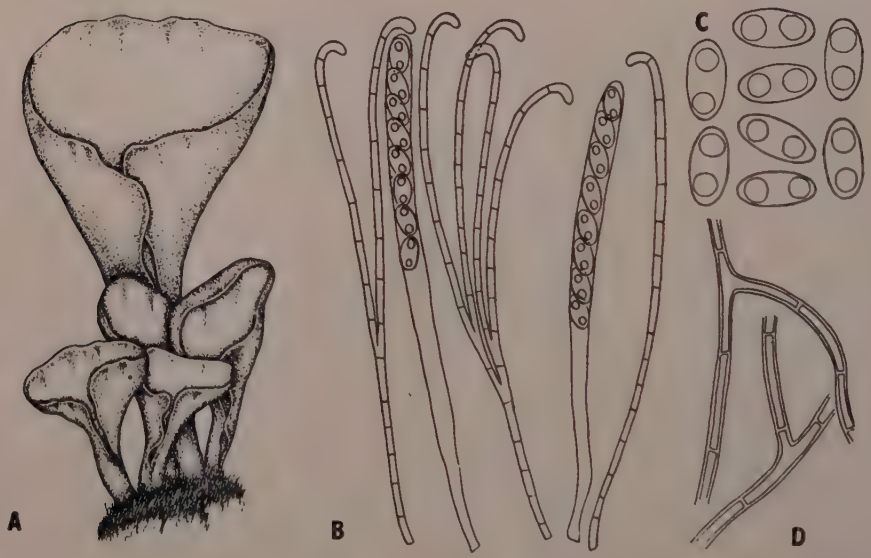
TEXT-FIG. 4. *Humaria stercorea* (Pers. ex Fr.) Fckl. Simple and branched hairs, ×130.

ceous), cylindrical or narrowly ellipsoid, ends rounded, smooth, biguttulate.

Paraphyses 140–184×1·8–3·2 μ, 3·6–5·4 μ wide at the top, ochraceous individually, yellowish brown in a mass, slender, filiform, septate, simple to branched, strongly hooked (or bent) at the top, slightly enlarged at the top, hooks smooth.

Text-Fig. 5, A—D.

Collected on humicolous soil under Oak Forest, Dhobi Khad, Mussoorie, September 1, 1956, **300**; on humicolous soil under Oak Forest, Kanatal, Mussoorie, September 12, 1957, **301.** New Record in India.



TEXT-FIG. 5. *Otidea Smithii* Kanouse. A. Apothecia, ×½. B. Asci and Paraphyses, ×400. C. Ascospores, ×950. D. Mycelial hyphæ from the soil, ×400.

These Mussoorie collections undoubtedly belong to *Otidea Smithii* Kanouse and are characterized by the solid foot-like base which is composed of soil permeated by profuse mycelial hyphæ, large elongate, ear-shaped, dark brown apothecia, biguttulate, narrowly ellipsoid ascospores, and narrow paraphyses strongly hooked at the top. The asci of the Mussoorie collections are narrower, however.

37. *Aleuria rhenana* Fckl., Symb. Myc. 325, 1869

Apothecia 1–3 cm. in diameter and 1–3 cm. in height, up to 1 cm. deep, in large cæspitose clusters (up to 12 apothecia in a cluster), gregarious, deeply cupulate throughout, when young globose and pitcher-

like, later on expanding and becoming typically cup-shaped, regular, or contorted due to mutual compression, bright orange, fading slightly on drying, fleshy-tough (not gelatinous), strongly stipitate; external surface concolorous or very slightly lighter coloured, even, very finely and inconspicuously pubescent; excipular cells 10·8–41·4 μ in diameter, pale orange due to dense orange contents, rounded to polygonal, pseudoparenchymatous, thin-walled; margin entire to wavy to rarely lobed, lobes small, inturned in young, globose apothecia; hymenium bright orange, smooth, even, deeply concave; stipe 5 mm.–2 cm. long and 3–6 mm. wide, long, always clinging together in clumps, cylindric, lighter coloured than the external surface, whitish to very slightly light orange, abruptly expanding above into the apothecium, solid, stipes of the caespitose cluster closely adhered together and thereby becoming irregular and somewhat flattened at places due to mutual compression, tomentose, tomentum white; tomentose hairs 17·5–432×5·4–10·8 μ, hyaline, fine, slender, hypha-like, flexuous, 4–9 septate, simple or branched, apex rounded.

Asci 256–281×10·8–13·5 μ, cylindric, apex rounded, tapering below into a somewhat short stem-like base, not turning blue with iodine, operculate, slightly bulging out in the region of mature ascospores.

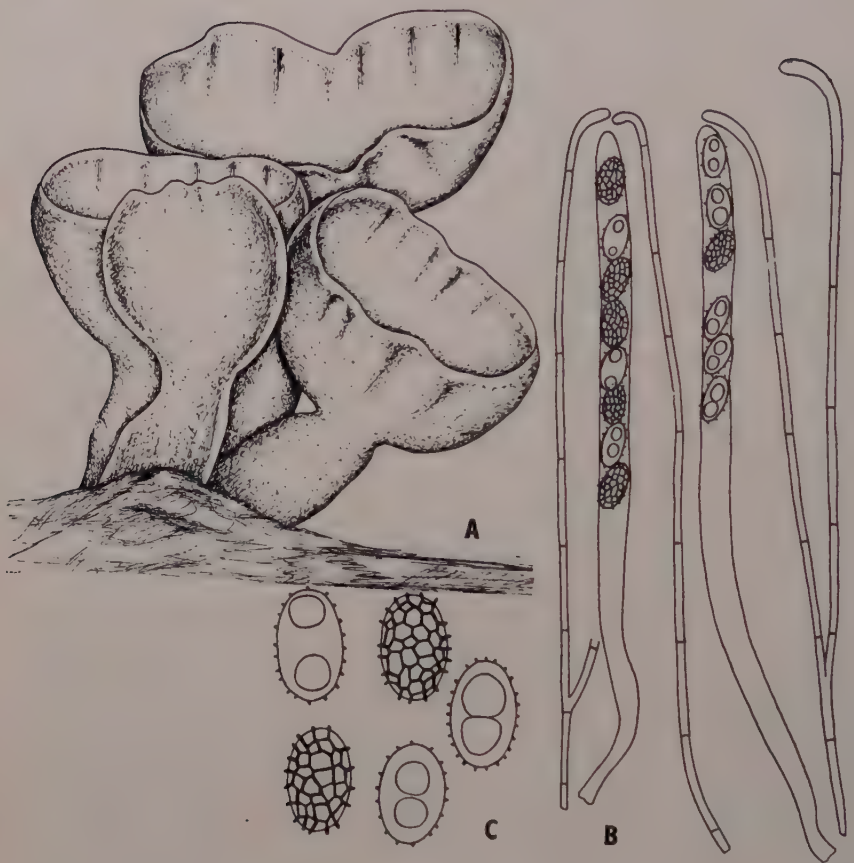
Ascospores 17·6–20×10·5–12 μ, 8 in number, uniseriate mostly oblique and with the ends overlapping, hyaline when young, becoming ochraceous at full maturity, smooth when young, becoming reticulate at maturity, reticulations complete, meshes polygonal, varying in size, 2·2–4·5 μ wide, edges of the reticulation ridges extending 1·1–2·2 μ beyond the periphery of the spore (thus the spore sculpturing appearing reticulate-verrucose), biguttulate, guttules small and far apart when young, becoming much bigger and closely apposed together in fully mature spores when they become inconspicuous and occupy three-fourth of the spore cavity.

Paraphyses 252–283×1·8–2·7 μ, 4·5–6·3 μ wide at the top, filiform, clavate, light orange to orange, septate, simple or branched, enlarged and slightly curved at the top.

Text-Fig. 6, A—C.

Collected on soil under Cedrus forest, Kadukhal, Mussoorie, September 9, 1955, **302;** on humicolous soil under *Picea morinda* forest, Kanatal, Mussoorie, August 20, 1956, **303**; on humicolous soil under *Quercus incana* Roxb. forest, Chakrata Toll, Mussoorie, September 6, 1957, **304**. New record in India.

This fungus seems to be quite common in the Mussoorie Hills but its occurrence is very sporadic. They occur mostly under coniferous forests and rarely observed in Oak Forest. All the Mussoorie collections belong to *Aleuria rhenana* Fckl. in several respects. However, their asci are not spirally twisted as reported for this species. Beside this the asci of these Mussoorie Collections are smaller as compared to those reported for the species.



TEXT-FIG. 6. *Aleuria rhenana* Fckl. A. Apothecia, ×5. B. Asci and Paraphyses, ×400. C. Ascospores, ×950.

38. *Humarina Gerardi* (Cooke) Seaver var. *gigantea* var. nov.

Apothecia 5–15 mm. diam., gregaria vel congesta, pallide violacea; ascosporæ 22·5–26·2×7·5–9·7 μ, biguttulatæ.

Apothecia 0·5–1·5 cm. in diameter, gregarious to densely gregarious to closely crowded together, globose when young, later on expanding and becoming shallow cupulate, and finally discoid to repand, regular, often contorted due to mutual compression, light violet, on drying turning dark brown, fleshy, slightly tough, smooth to almost smooth to slightly roughened, sessile or sub-stipitate (reduced below to a stem-like base); flesh concolorous, unchanging; taste and smell inparticular; external surface lighter coloured than the hymenium, *i.e.*, very light violet, slightly roughened; excipular cells 12·6–45 μ wide, hyaline individually, subhyaline in a mass, rounded to angular, thin-walled,

pseudoparenchymatous; margin entire, incurved in young apothecia; hymenium light violet, deeper coloured than the external surface, smooth, even, concave to plane.

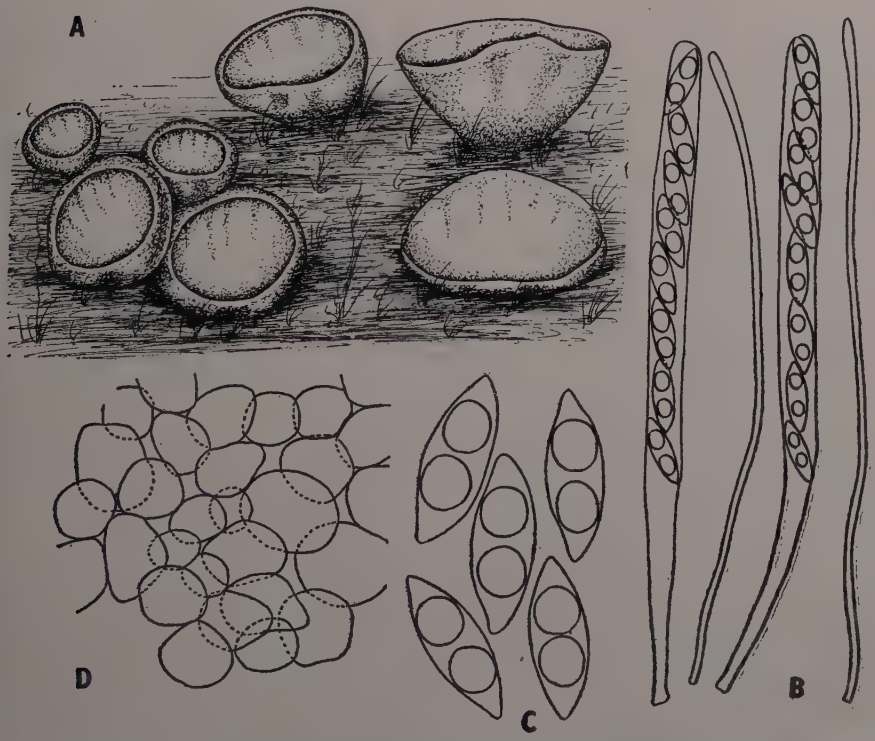
Asci 220–252×9–16·2 μ, cylindric-clavate, apex rounded to subtruncate, tapering below into a stem-like base, not turning blue with iodine, operculate.

Ascospores 22·5–26·2×7·5–9·7 μ, 8 in number, uniseriate, mostly oblique and overlapping, fusoid, ends very much narrowed and pointed, smooth, hyaline, biguttulate.

Paraphyses 236–279×2·7–3·6 μ, 3·6–5 μ wide at the top, hyaline individually, sub-hyaline in a mass, slender, thin, non-septate, simple, usually very slightly and gradually enlarged upward.

Text-Fig. 7, A—D.

Collected on humicolous soil under Oak Forest, The Park, Mussoorie August 30, 1957, **305**. New record in India.



TEXT-FIG. 7. *Humarina Gerardi* (Cooke) Seaver var. *gigantea* var. nov. A. Apothecia, ×3. B. Asci and Paraphyses, ×400. C. Ascospores, ×950. D. Excipular cells, ×400.

This Mussoorie collection undoubtedly belongs to *Humarina Gerardi* (Cooke) Seaver but markedly differs from it in the possession of much larger apothecia (5–15 mm. in contrast to 4–5 mm. as reported for this species) and smaller ascospores (22·5–26·2 μ long in contrast to 30–35 μ long as reported for this species) which are uniformly biguttulate. Because of the large size of the apothecia the Mussoorie fungus has been named as a new variety *gigantea* var. nov.

Acknowledgements

The authors are highly indebted to Miss Edith K. Cash of U.S. Department of Agriculture, Beltsville, Maryland, for her help in the identification of the species and valuable suggestions and Prof. P. N. Mehra for encouragement and facilities. They are also thankful to Mr. B. Khanna for help in making the illustrations of the fructifications.

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INFLUENCE OF CERTAIN GROWTH SUBSTANCES ON COTTON PLANT

I. Effect of *b*-Naphthoxy Acetic Acid on Boll-Retention in *Gossypium arboreum* var. 35/1

By S. N. Mathur

Department of Botany, Meerut College, Meerut

(Received for publication on November 5, 1958)

Introduction

With the loss of the cotton-belt in Sind and West Punjab due to partition of India, the necessity to increase the area under improved strains of cotton has been keenly felt both in East Punjab and Western Uttar Pradesh. *Gossypium arboreum* var. 35/1, an improved strain of desi cotton, has generally replaced other local strains in Western Uttar Pradesh due to its better yield and quality of fibre. Still the problems relating to further improvement in growth and yield by controlling production and shedding of flowers and bolls are to be solved, not only for this strain of desi cotton but also for the American cottons which are in greater demand because of their better lint-length. Studies were, therefore, undertaken in order to investigate the effect of some phytohormones on growth, bolling and C/N ratio in desi cotton and in *G. hirsutum* var. L.S.S., an improved selection of American cotton grown in the Eastern Punjab. The present paper deals with the effect of *b*-Naphthoxy acetic acid on boll-retention and reproduction in desi variety.

Material and Methods

Seeds of *G. arboreum* var. 35/1, obtained from the Economic Botanist (cotton) to the Government of Uttar Pradesh, were sown in 30·0×30·0 cm. pots containing two parts of garden soil and one part of compost on April 16, 1956, about a month earlier than the normal sowing date at Meerut (Western Uttar Pradesh). The plants were thinned out to one in each pot when they were three weeks old. An aqueous solution of *b*-Naphthoxy acetic acid (20 p.p.m.) was sprayed with a hand-atomiser every alternate week in the morning hours beginning on May 5, 1956 at the four-leaf stage of the plants. In all six sprayings were done on twenty plants, and an equal number of plants was kept as control. Weekly observations on vegetative and reproductive characters were taken for twenty weeks and standard errors were calculated for the means.

Observations

Vegetative Characters.—The average height of the treated plants was more than the control up to five weeks after first treatment and

statistically significant in the first three weeks, but from sixth week onward the effect was reversed (Fig. 1). The control plants continued their normal growth and attained normal height (105·9 cm.) at maturity, while the treated plants showed loss of apical dominance, remained shorter (mean height—95·7 cm.) and bushy as more lateral branches developed.

Regarding the main-stalk node number, the treated plants were taller in the beginning than the controls. This, however, was not due to the elongation of internodes, but due to the greater number of nodes on the main-stalk and the difference was statistically significant in the first five weeks. A maximum difference of 1·4 in node number in favour of the treatment occurred after two sprayings. The effect, however, disappeared in about a month and at maturity the node number in the treated plants was only 36·3 compared to 39·2 of the controls.

With the increase in height and node number the treated plants bore more leaves (5·6 to 18·6) in the beginning for five weeks than the controls which showed 4·8 to 18·2 leaves for the same period, but with prolonged treatment, reduction in height, node number and the number of main-stalk leaves was observed and at maturity, the treated and the control plants bore only 13·5 and 15·2 leaves respectively (Text-Fig. 1).

Reproductive Characters.—The treated plants developed more fertile branches than the controls (Text-Fig. 2). Treatment with NOA also resulted in profuse formation of flowers in the first two weeks of flowering (mean number 6·5 and 12·9) compared with 4·5 and 9·4 respectively of the control. Even in the third week the flower number was higher for the treated subjects, but in the four subsequent weeks the number was reduced. Later, there was again an increase, but ultimately the number of flowers formed in the two sets was nearly the same (67·9 in the treated and 67·0 in the control plants).

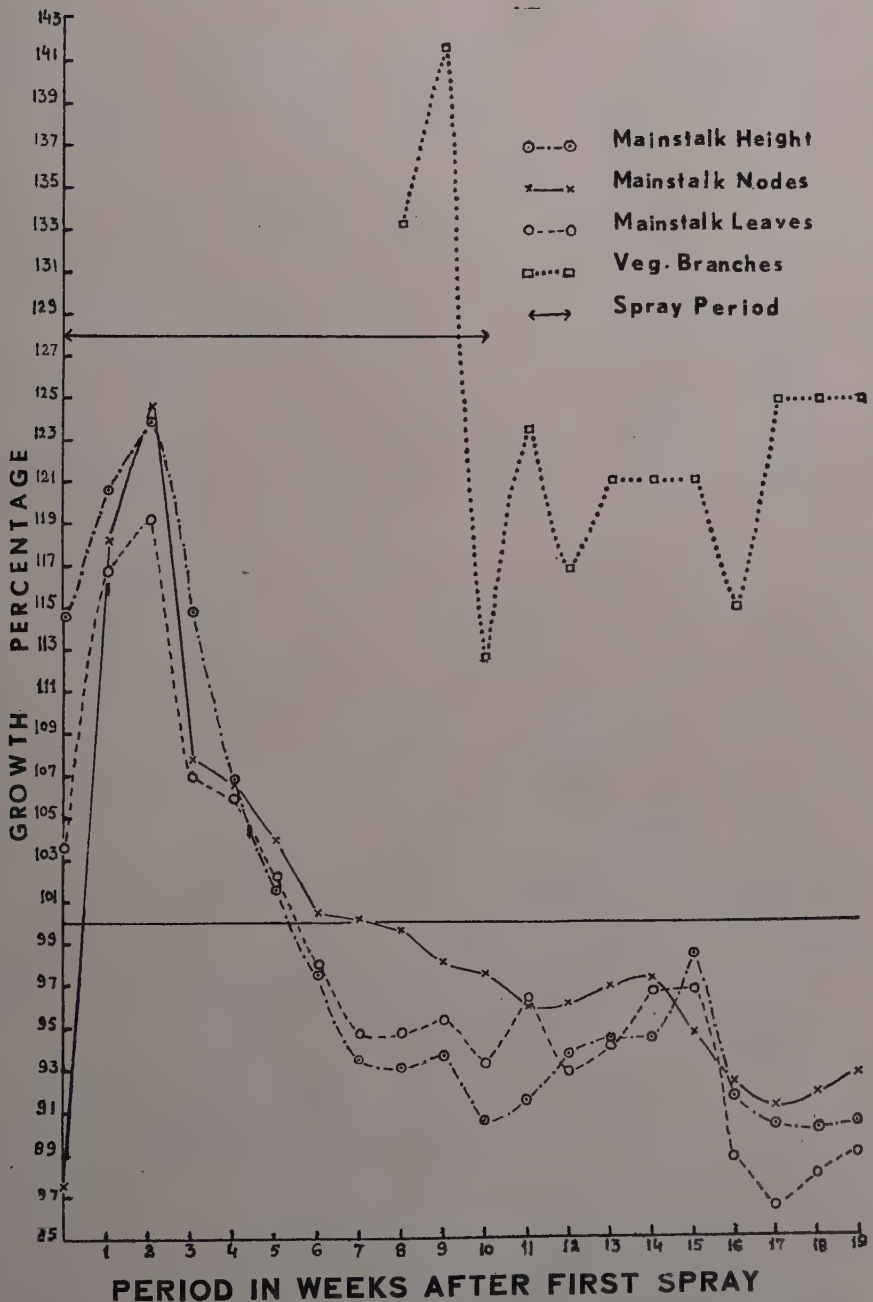
Also, shedding of flowers increased with spraying in the first five weeks but ultimately the difference between the control and treated sets was negligible.

In the first four weeks of bolling the treated plants retained less number of bolls (1·9–5·1), while the control plants retained more (2·4–5·3), but later on the boll number increased in the treated plants. Shedding of bolls, however, was less in treated than in control plants significantly in the first five weeks, but nearly the same number of bolls was shed in both sets at maturity (Text-Fig. 2).

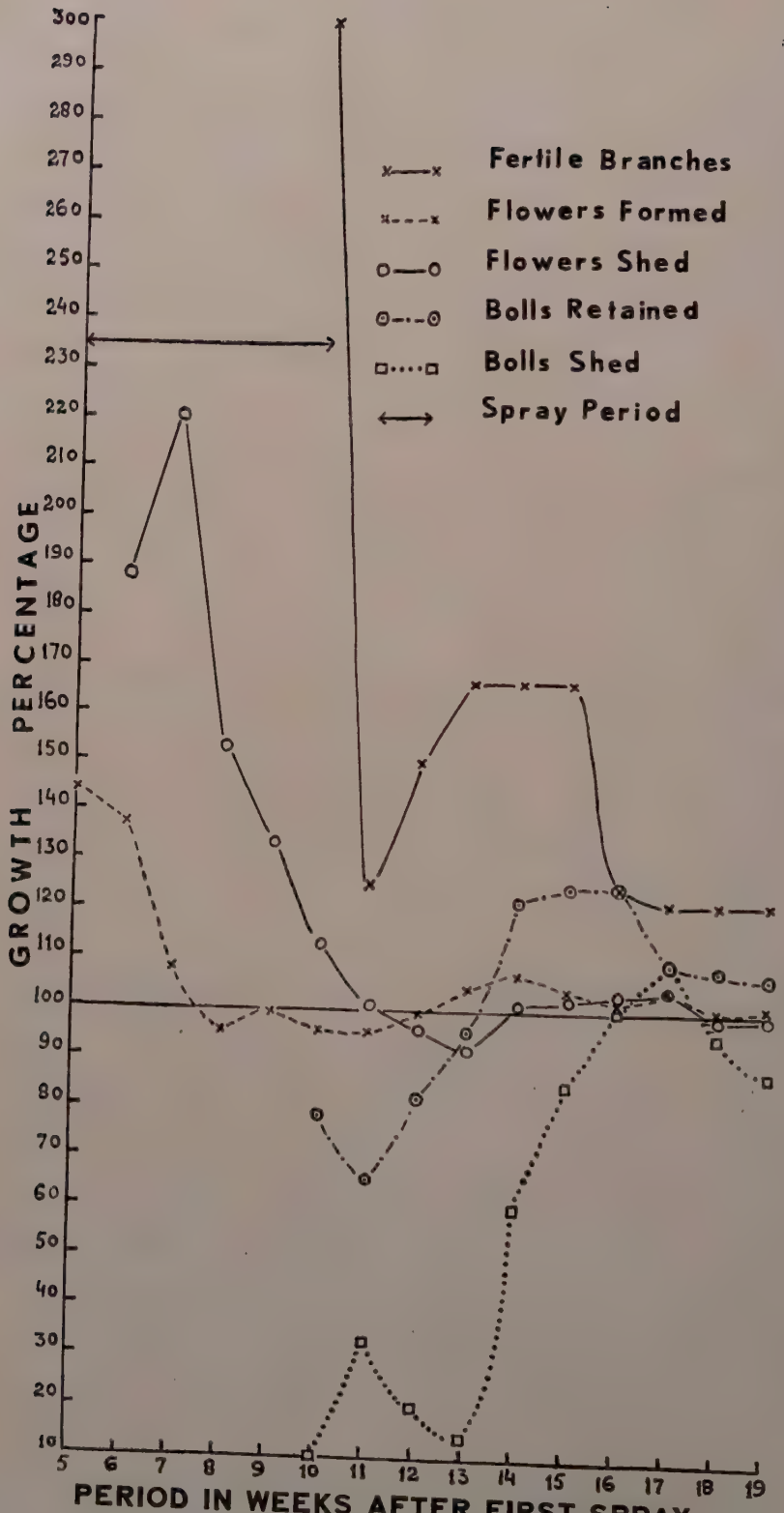
Discussion

In order to reduce boll abcission Singh and Greulach (1949) treated cotton plants with *a*-Naphthalene acetic acid and its amide, but obtained only negative results.

Eaton (1950) investigated the effect of sodium salts of 4-Chlorophenoxy acetate, Naphthalene acetate and *b*-Naphthoxy acetate on boll-retention in cotton and concluded that 4-Chlorophenoxy acetate



TEXT-FIG. 1. Effect of *b*-Naphthoxy acetic acid on vegetative characters in *Gossypium arboreum* var. 35/1. Graph based on percentage over control.



TEXT-FIG. 2.—Effect

decreased the number of bolls per plant; Napthalene acetate was without significant effect, while *b*-Naphthoxy acetate increased significantly the setting of bolls. Dastur and Prakash (1954) and Bhatt and Date (1955) also found a significant increase in boll number by the application of *b*-Naphthoxy acetic acid and Naphthalene acetic acid respectively.

The present findings are in agreement with the results of the previous workers. Bausor (1939) found a cessation of apical growth in tomato plants smeared with lanolin containing 0·1–1·0 per cent. *b*-Naphthoxy acetic acid. This is also true in cotton plant as a consequence of which more lateral branches are formed (van Overbeek, 1938; Bausor, 1939); the main-stalk nodes and leaves are reduced and the plants dwarfed. This might possibly be due to excessive spraying of the growth substance which destorys the stimulating agent, *viz.*, the native hormone (Skoog *et al.*, 1942) in the apical cells. Spraying did not cause any apparent change in the colour or flaring of the margins, or swelling and condensing of veins in leaves (Eaton, 1950). However, spraying cotton plants with 2, 4-D has shown these effects (Mathur, unpublished work).

In the reproductive phase the treatment had a marked effect especially on the number of fertile branches, flowers and bolls formed and shed. The number of flowers formed during the spray period (3·2–25·9 in the treated and 1·7–22·9 in the control) and their simultaneous shedding were definitely more in the treated plants. Greater shedding in the early period was probably due to enhanced respiratory activity causing a depletion of carbohydrates and thus a nutritional deficiency (Bonner and Bandurski, 1952), but subsequently normal bolling occurred. Boll-retention was higher in the treated plants as also reported by Eaton (1950), Dastur and Prakash (1954) and Bhatt and Date (1955).

Summary

1. An aqueous solution of *b*-Naphthoxy acetic acid (20 p.p.m.) was sprayed on *G. arboreum* var. 35/1 plants from 4-leaf stage onwards on alternate weeks. Weekly observations of vegetative and reproductive characters were taken for twenty weeks.

2. The treatment markedly affected the height, and the number of main-stalk nodes and leaves. An initial stimulation followed by depression was noted in the treated plants.

3. Treated plants developed more fertile branches and retained more bolls than the controls.

Acknowledgements

I am greatly indebted to Dr. I. M. Rao for the guidance and to Professor V. Puri for providing research facilities. Thanks are also due to the Economic Botanist (Cotton), U.P., for providing seeds of *G. arboreum* var. 35/1.

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RESPONSE OF TEA BUSHES TO FOLIAR APPLICATION OF FERTILISERS

By K. S. Venkataramani*

U.P.A.S.I. Tea Experiment Station, Devarshola, The Nilgiris

(Received for publication on November 19, 1958)

The correction of trace element deficiencies in plants by spraying the leaves with appropriate solutions is now an accepted practice and much interest is evinced at present in feeding plants with foliar sprays. The application of plant nutrients to the foliage of an agricultural or horticultural crop is still a relatively new technique and further research is indicated. It is recognised that application of plant foods in a liquid or spray form to tea bushes [*Camellia sinensis* (L.) O. Kuntz.] on a plantation scale is not a practicable proposition. The reasons are obvious. Foliar application of nutrients, therefore, can only supplement solid fertilisers applied to the soil in the usual way. However, it may be useful under certain conditions, when soil nutrients are not readily available and for detecting and curing deficiencies. An experiment was undertaken by us to ascertain whether tea bushes, in a field where potash deficiency was suspected, would respond to foliar application of fertilisers in the form of dilute solutions. The preliminary observations have been published elsewhere (Venkataramani, 1956) and full details of the experiment, comprising data collected during the period October 1954 to December 1956, are presented in this paper.

Materials and Methods

A uniform area of tea, which was originally weak but was rested (left without plucking) for about two years and later pruned and brought back to plucking, was selected for the experiment 13 months after pruning. Some bushes in this field exhibited foliar symptoms of potash deficiency and the secondary leaf diseases, brown blight (*Colletotrichum camelliæ* Massee) and grey blight (*Pestalotia theæ* Sawada) were also noticed on such bushes.

The experimental area was divided into 18 plots, each of 200 tea bushes. The experiment consisted of three treatments, each replicated six times. The plots for the different treatments in each of the six blocks were marked at random and prior to the application of the spray treatments, they were harvested individually for eight rounds of plucking from October 1954 to December 1954, in order to make sure that the plots were as uniform as possible in their yielding capacity.

* Present address: Reader in Horticulture, Post-graduate Agric. Res. Institute, Lawley Road, Coimbatore.

No fertiliser was applied to the soil at the start of the experiment (December 1954), but the field was manured in March 1954 (80 lb. N and 40 lb. K_2O per acre), and the treatments consisted of the following:—

(i) Control (No application of fertilisers).

(ii) Application of potash in the form of 1·0% muriate of potash to give 52 lb. K_2O per acre per year, and

(iii) Application of a NPK mixture (1·25% crystalline urea, 1·0% superphosphate and 1·0% muriate of potash) to give 50 lb. N, 15 lb. P_2O_5 and 52 lb. K_2O per acre per year. These concentrations of fertiliser ingredients were found to be safe for spraying tea bushes and they were based on the results of some preliminary foliar spray trials carried out by Mr. S. Ananda Rau and myself. While preparing the spray solution, the superphosphate was separately dissolved in a small volume of water and the undissolved residue was discarded.

The fertilisers were applied in equal doses during two periods, December and April, and at each period they were applied in equal amounts in three or four rounds of spraying, at four- to five-day intervals, at the rate of 108 gallons of the spray fluid per acre per round. This volume of fluid was found necessary to wet the foliage and the branches thoroughly without causing pronounced dripping. The bushes were left out of plucking during the period of spray application and for about a week after the last application of the spray. Thereafter the plots were harvested according to the usual estate practice and yield records of individual plots were maintained from January 1955 to December 1956. Fresh weight of the plucked leaf was employed for comparison throughout the experiment. It is now confirmed that fresh weight yields and dry weight yields are highly correlated and pluckings based on fresh weights would provide a reliable basis for long-term yield determination (Visser, 1958).

The first treatment for the first year of the experiment was commenced in December 1954 and that for the second year was given in December 1955. In the first year, the control (no fertiliser) plots received spray applications of water during the December spraying to obviate the possibility of water alone giving an increase in crop, but this was discontinued later as it was found that few sprayings with water alone did not materially affect the treatment effect.

From a random selection of 20 bushes in one plot of each treatment, 20 branches formed after pruning, one in each bush, were marked and labelled. The girth of these individual branches, at a point one inch above their union with the parent branches, was measured at the commencement of the experiment and again 10 and 23 months after the first application of the fertiliser sprays in order to find out whether the treatments have had any effect on the growth of these branches. The method followed for the analysis of the results was based on that

given by Paterson (1939) for the determination of significance of a difference between means of small samples.

Experimental Results

Table I

Preliminary yields for 8 *plucking rounds* (*October to December* 1954) *before the commencement of spraying*

Plots marked for	lb. green leaf from 6 plots (1,200 bushes)
Control	562
Potash spray	575
NPK spray	575

The difference in yield between the plots marked for the control (no fertiliser) and fertiliser spray treatments is not statistically significant and this confirms the uniformity of yields of the plots.

Table II

Rainfall data for 1955 *and* 1956

Period	No. of rainy days		Rainfall in inches	
	1955	1956	1955	1956
January/March	2	5	0·17	1·22
April/June	57	51	35·46	27·73
July/September	71	72	25·08	26·80
October/December ..	28	38	9·29	14·63
Total ..	158	166	70·00	70·38

The trend of the rainfall was essentially the same during the different periods in the years 1955 and 1956.

TABLE III

Yield data for the year 1955 *in lb. green leaf for* 6 *plots* (1,200 *bushes*)

Treatment	Jan. to March	April to June	July to Sept.	Oct. to Dec.	Total
Control	282	573	576	541	1972
Potash sprayed ..	324	625	719	624	2292
NPK sprayed ..	350	618	702	615	2285
Difference required for significance					
At P = 0·05 ..	38	..	116	..	284
At P = 0·01 ..	54	..	..	..	..

The bushes sprayed with potash and NPK spray have yielded higher than the control (untreated) ones. During the dry weather period January to March 1955, the difference in yield between the fertiliser sprayed bushes and that of the control ones was significant. During the other periods, as expected, the treated bushes have always yielded more than the control ones, but the difference between the yields of the fertilised and that of the control bushes was significant only during July to September. The difference in yields between the potash and NPK sprayed bushes was not statistically significant.

TABLE IV

Yield data for the year 1956 *in lb. green leaf for* 6 *plots* (1,200 *bushes*)

Treatment	Jan. to March	April to June	July to Sept.	Oct. to Dec.	Total
Control	267	335	407	584	1593
Potash sprayed ..	357	390	489	713	1949
NPK sprayed ..	404	411	507	721	2043
Difference required for significance					
At P = 0·05 ..	45	..	..	..	346
At P = 0·01 ..	63	..	..	..	..

The fertiliser sprayed bushes have again yielded more than the control ones. During the period January to March 1956, the yields obtained from the potash and NPK sprayed plots were greater than that from the control ones, the difference in the yields being highly significant. The NPK sprayed bushes have yielded a little more than the potash sprayed bushes and the difference in these yields being just significant at the 5·0 per cent. level during this period. Even during the other periods, the NPK sprayed bushes have always yielded more than those which received the application of potash alone, but the differences are not statistically significant.

TABLE V

Decrease in yield (in lb. green leaf for 6 plots, i.e., 1,200 bushes) in the different treatments from the 1st year to the 2nd year of the experiment

Control	.. 379
Potash sprayed	.. 343
NPK sprayed	.. 242

The field, in general, has shown a decrease in yield during the second year of the experiment (*i.e.*, during the third year after pruning), conforming to "the early maximum pattern" (Eden, 1946). Comparing the yield during the second year of the experiment from that obtained in the first year, it can be observed that the decrease was greatest in the case of the untreated bushes and that it was the least in the case of those sprayed with the NPK mixture.

In general, the branches of the bushes sprayed with the fertilisers have made marked increase in girth. The branches of the NPK sprayed bushes have shown the greatest increase, but the difference between the increases in girth of the branches of the NPK and potash sprayed bushes is not statistically significant.

DISCUSSION

This experiment has shown that tea bushes are able to absorb nutrients through their foliage and that in the field the bushes responded to foliar application of fertilisers. The bushes sprayed with potash and the NPK mixture have given significant increases in yield over that obtained from the untreated (control) bushes. Increased yields from tea bushes sprayed with urea solutions have been reported already from China (Chiang, 1954 *a*).

One point of particular interest has emerged out of this experiment. Comparing the yield data on a three-monthly basis (Tables III and IV) a highly significant difference was obtained in the period January to

TABLE VI

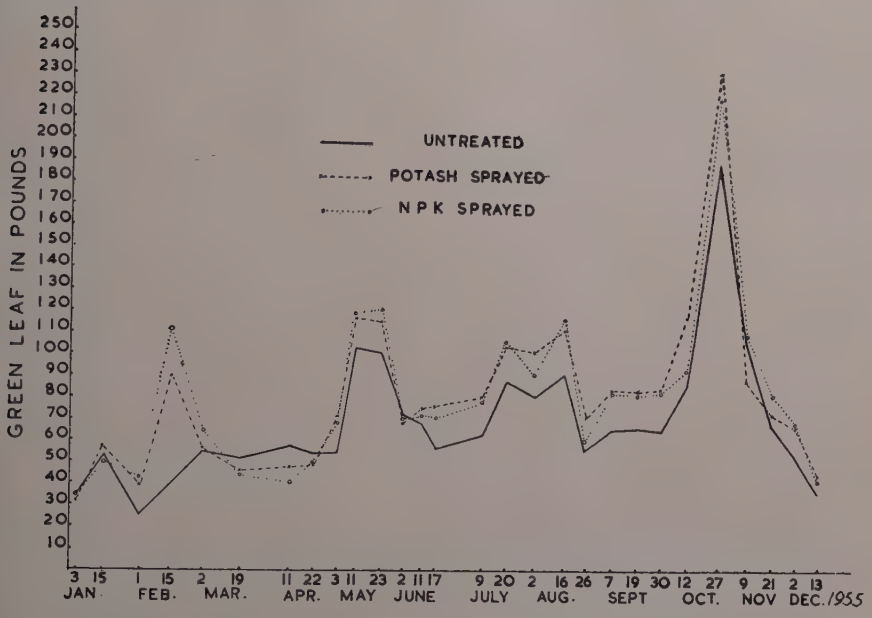
Average increase in girth (expressed as increase in diameter) over the initial girths of 20 branches in each treatment

Treatment	% increase in girth at the end of	
	10 months	23 months
A. Control	11·6	26·3
B. Potash sprayed	17·2	37·5
C. NPK sprayed	19·6	39·3
Significant difference between A and B		
at P = 0·05	2·6	7·6
at P = 0·01	3·5	10·0
Significant difference between A and C		
at P = 0·05	2·3	6·0
at P = 0·01	2·9	8·0
Significant difference between B and C ..	(Not significant)	

March in both years 1955 and 1956. In the other periods, such a significant difference in yield was not obtained, particularly in the year 1956. The period January to March is usually a dry one with very little rainfall (Table II) and is considered to be the drought period in this tea growing district. This would indicate that the bushes respond well to foliar application during that period when nutrient absorption from the soil is naturally restricted. It looks as though the time at which the spray applications are made has a pronounced effect on the result. One may even argue that during dry weather the water in the spray may have influenced the growth of the bushes. To obviate this, in the first series of spraying, the control (unfertilised) bushes were sprayed with water. As the differences in yields obtained from the control bushes and those sprayed with potash and the NPK mixture were highly significant during the period January to March, it was considered that the marked increase in yields obtained during that period was due to the fertilisers and not to water alone contained in the spray. It was, therefore, decided to discontinue spray applications of water to the control bushes during the subsequent fertiliser applications.

Increase in yield was obtained from the bushes sprayed with fertilisers during the dry period for a few rounds of plucking immediately

following the spray application. Thereafter the yield from the treated bushes fell below that of the untreated ones for a very short period, but following the second series of spraying in April and with the onset of the rains (Table II) and favourable conditions for growth, the fertiliser sprayed bushes have almost always yielded more than the control ones (Text-Figs. 1 and 2).

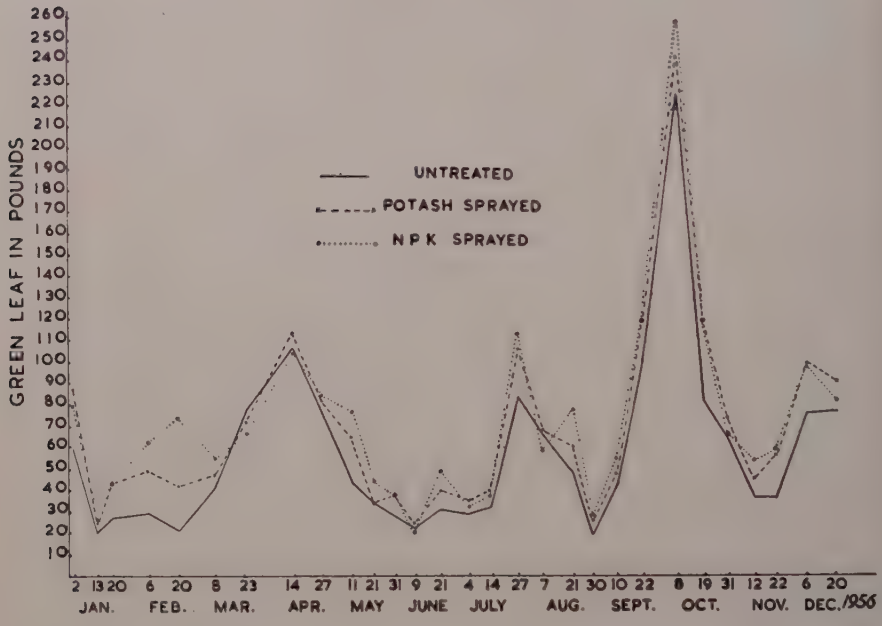


TEXT-FIG. 1. Treatment yield at individual plucking in the year 1955.

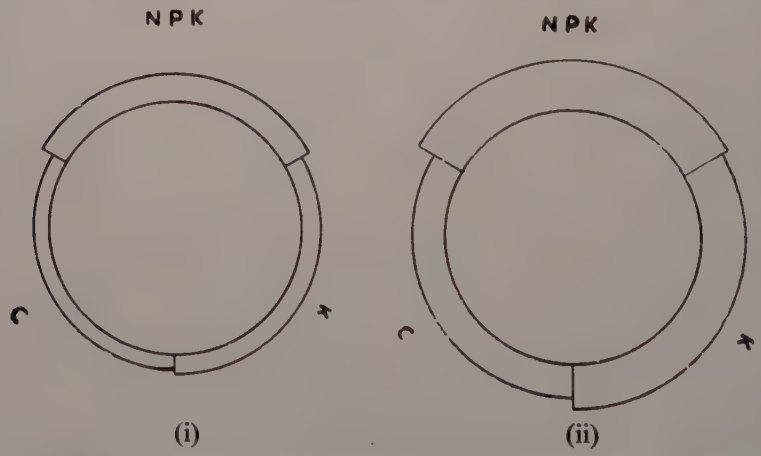
During the first year of the experiment (1955), the yield response of the bushes sprayed with potash alone and those sprayed with the NPK mixture was pratically the same (Table III and Text-Fig. 1). In the second year (1956), the bushes sprayed with the NPK mixture have almost always yielded more than those sprayed with potash alone, although the differences are not statistically significant except during the period January to March 1956 (Table IV and Text-Fig. 2). Similarly, in growth also, the bushes, which received the NPK spray have shown a higher figure for girth measurements than those which received spray applications of potash only (Table VI and Text-Fig. 3). However, the difference in the growth made by the NPK and potash sprayed bushes is not significant. The two fertiliser treatments have very significantly increased the girth of the branches, as compared with the growth made by the branches of the untreated bushes.

The observations recorded above, however, do not mean that potash alone can replace a complete manure mixture. It must be remembered that the field chosen for the experiment was by no means healthy. In fact, the bushes were originally weak and were rested

(thrown out of plucking) for a while to recoup their health. It is not surprising, therefore, that a good response, as expressed by yield and



TEXT-FIG. 2. Treatment yield at individual plucking in the year 1956.



TEXT-FIG. 3. Diagrammatic representation of the increase in girth of the branches of tea bushes (i) 10 and (ii) 23 months after the commencement of the experiment. The inner white circle represents the initial average girth of the branch. Arcs C, K and NPK represent the increase in size in the untreated, potash and NPK mixture sprayed bushes,

girth measurements, was obtained with potash alone during the first year of the experiment. When absorption of a nutrient by the leaves increases growth, there is an accompanying increase in uptake by the root of other nutrients (Thorne, 1957), and in this instance it is likely that absorption of potash by the leaves may have increased the uptake of other nutrients available in the soil by the roots of the treated bushes.

In the second year of the experiment, the bushes sprayed with the NPK mixture showed a better response than those which received spray applications of potash alone during the period January to March, the difference in yield being significant at the 5 per cent. level (Table IV). The bushes which received foliar applications of the NPK mixture have always yielded more than those sprayed with potash even during the other periods (Text-Fig. 2), although no statistical difference was discerned. The decrease in yield from that obtained in the first year of the experiment was lowest in the case of the bushes treated with the NPK mixture (242 lb.), and it was only slightly lower in the case of those sprayed with potash (343 lb.), as compared with the untreated bushes (379 lb.) which recorded the greatest decrease (Table V). Had the experiment been continued for a longer period, the bushes sprayed with the NPK mixture might have shown a still better response to the foliar application of fertiliser than those sprayed with potash alone.

Increased yields have never been obtained in tea with soil applications of phosphates in the various trials carried out in Southern India (Jayaraman, 1958). In the experiment reported in the present paper, we have not unfortunately included a separate treatment for phosphate alone and, therefore, are unable to say categorically whether foliar application of phosphate alone would increase the yield. But, our primary aim in carrying out this experiment was to see whether tea bushes in that particular field would respond to foliar applications of potash. It may be of interest to add here that foliar application of phosphate alone had no significant effect on yield of tea in China and that it was also not found to have any interaction with urea (Chiang, 1954 *b*).

The uptake of one nutrient by the leaves is the same whether it be applied alone or in a mixed spray with other nutrients (Thorne, 1957), and we could, therefore, expect appropriate increase in yield when two or more essential nutrients are applied together. This would explain why the bushes sprayed with the NPK mixture have always yielded more than those which received only spray applications of potash, especially during the second year of the experiment. We realise that nitrogen and potash applied to the bushes in this experiment were not correctly balanced and that with more nitrogen than what was supplied to the bushes, they might have shown a still better response to the foliar application of the NPK fertiliser mixture than to the application of potash alone.

These results would indicate that foliar application of potash to tea bushes deficient in that essential nutrient, together with proper bush management, would help them to recover from their weakness,

provided the debility is not too far advanced. In a plantation crop like tea foliar application of fertilisers cannot replace soil application and at best it can only supplement soil dressings of fertilisers. The practical difficulty of feeding tea plants with sprays of macro-nutrient elements has been discussed already elsewhere (Jayaraman, 1958).

Summary

This paper details the results obtained during the course of two years from an experiment on foliar application of fertilisers to tea bushes.

Increased yields were obtained by spraying the foliage with potash and NPK mixture, the difference in yields of the fertiliser sprayed and untreated bushes being highly significant during the dry weather.

The response of the tea bushes to foliar spray of fertilisers was also measured by girth measurements of branches and it was observed that the branches of the treated bushes made a marked growth as compared with those of the untreated bushes.

The experiment was conducted in a tea field which was suspected to be deficient in potash and the results of this trial indicate that debilitated tea bushes in such fields respond to foliar application of potash and that, with proper bush management, they could be nursed back to health, provided the debility is not far advanced.

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PADDY FIELD WEED FLORA OF THE STATE AGRICULTURAL FARM, CHINSURAH (WEST BENGAL)

By A. K. Paul and R. K. Bhattacharyya

Department of Agriculture, West Bengal

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Like all other cultivated crops, paddy is not free from its weeds and a number of them have been found in the paddy fields. The weeds, as they are commonly called—the unwanted plants, have no species of themselves. Muenscher (1947) observed that a plant species is considered as a weed depending not only on its characteristic and habits but also to its relative position with reference to other plants and human beings.

The weeds compete with the cultivated crops for water, nutrients and light and thus bring serious damage resulting in poor yield of crops (Panikar, 1950; Asana, 1951). In an estimate in the reduction of yield of crops in general by the weeds, Luthra (1938) calculated the loss to be up to 30%. Tiwari (1953–54) in Bihar, estimated the loss to be of 33% and 21·6% respectively for two successive years due to weeds on different varieties of paddy. He further observed that the weeds are more injurious in the early stages than in the advance stages of the crop. Haq (1955) observed a correlation between the weed population and the yield of paddy. The report of the Agricultural Service Department Committee, U.S. Chamber of Commerce, of the year 1930 (quoted by Thakur, 1954) gave statistical figure of $ 3,000,000,000 as loss due to weeds alone.

Different methods, *e.g.*, cultural, mechanical, biological, chemical and growth-regulating substances are being used for the control of weeds and have got their own merits and demerits. Asana (*loc. cit.*) observed the possibilities of the application of weedicides under the Indian conditions and remarked that in general its use in grain crops all over the country cannot at present be recommended in the absence of reliable information. In an effort to find out some methods for the control of weeds in the paddy fields of eastern U.P., Haq (*loc. cit.*) observed that the cultural practices like thorough ploughing, sowing at optimum time and sowing of germinated seeds by puddling minimized the weeds population.

Prain (1905) surveyed the flora of the Hooghly district in general and listed about thirty-three species occurring in paddy fields as weeds. A preliminary survey of the weed flora of the paddy fields of West Bengal was made by Chakrabarty (1957) during the year 1938–40. He recorded eighty-seven species which were collected from the paddy fields of Chinsurah, Bankura and Suri State Agricultural Farms representing

the alluvial and laterite tracts of West Bengal. Some of his weeds were found to be common with those of Prain (*loc. cit.*). The present investigation was carried out with a view to find out the change, if any, in the paddy field weed flora of the State Agricultural Farm, Chinsurah, due to rotation and cultural operations practised with the crop which may encourage or discourage the specific weeds during these years.

Material and Method

Paddy fields of the Farm can be divided into—low, medium and high lands. The weeds were collected from all types of land and only at the time of the paddy season. *Aus* paddy remains in the field from June to September, *Aman* from July to January and *Boro* paddy from November to April. The collection was confined only with the angiospermous plants which was started from the month of August, 1953, and continued upto September 1955. The plants were preserved as herbarium specimens. The list of weed species with their families and the type of lands on which they were observed are given below:—

Sl. No.	Species	Family	Type of land
		Dicotyledons	
1.	*Hygrophila spinosa* T. And.	Acanthaceæ	Medium
2.	*Celosia cristata* Linn.	Amarantaceæ	High
3.	*Psilotrichum ferrugineum* Moq.	,,	,,
4.	*Eriocaulon quinquangulare* Linn.	Compositeæ	Medium
5.	*Ipomœa reptans* Poir.	Convolvulaceæ	,,
6.	*Euphorbia hypercifolia* Linn.	Euphorbiaceæ	High
7.	*Erythræa roxburghii* G. Don.	Gentianaceæ	Medium
8.	*Limnanthemum cristatum* Griseb.	,,	Low
9.	*Myriophyllum indicum* Roxb.	Halorageæ	,,
10.	*Utricularia stellaris* Linn.	Lentibulariaceæ	Medium-Low
11.	*Ammania multiflora* Roxb.	Lythraceæ	Medium
12.	*Rotala leptopelata* Kœhne.	Lythraceæ	,,
13.	*Nymphæa stellata* Willd.	Nymphæaceæ	Low
14.	*Jussiæa repens* L.	Onagraceæ	Medium
15.	*Ludwigia parviflora* Roxb.	,,	,,
16.	*Aeschynomene aspera* Linn.	Papilionaceæ	Low
17.	*A. indica* Linn.	,,	,,
18.	*Sesbania paludosa* Prain.	,,	,,
19.	*Dopatrium junceum* Buch Hen.	Scrophulariaceæ	Medium
20.	*Limnophila gratioloides* R. Br.	,,	,,
21.	*Lindernia parviflora* Haines.	,,	,,
22.	*L. tenuifolia* Alston.	,,	,,
23.	*Pentapetes phœnicea* L.	Sterculiaceæ	Medium-Low
		Monocotyledons	
24.	*Aneilema vaginatum* R. Br.	Commelinaceæ	Medium
25.	*Commelina benghalensis* Linn.	,,	,,
26.	*C. obliqua* Ham.	,,	,,
27.	*Cyperus dilutus* Vahl.	Cyperaceæ	Medium-Low
28.	*C. grossus* Linn. F.	,,	,, ,,
29.	*C. haspan* Linn.	,,	,, ,,
30.	*C. iria* Linn.	,,	,, ,,

Sl. No.	Species	Family	Type of land
	MONOCOTYLEDONS—(*Contd.*)		
31.	*C. pilosus* Vahl.	Cyperaceæ	High, Medium and Low
32.	*C. pracerus* Rottb.	,,	Medium-Low
33.	*C. rotundus* Linn.	,,	High, Medium and Low
34.	*C. silletensis* Nees.	,,	Medium
35.	*C. zollingeri* Stead.	,,	Medium-Low
36.	*Eleocharis plantaginea* R. Br.	,,	,,
37.	*Fimbristylis complanata* Link.	,,	Medium
38.	*F. miliacea* Vahl.	,,	,,
39.	*Scirpus articulatus* Linn.	,,	Medium Low
40.	*S. supinus* Linn.	,,	,, ,,
41.	*Eragrostis amabilis* W. & A.	Graminaceæ	Medium
42.	*E. tenella* R. & S. var. *plumosa* Stapf.	,,	High
43.	*Echinochloa colona* Link.	,,	High-Medium
44.	*E. crus-galli* Beauv.	,,	High, Medium and Low
45.	*Hemarthria compressa* R. Br.	,,	Medium
46.	*Ischæmum rugosum* Salisb.	,,	High-Medium
47.	*Leersia hexandra* Sw.	,,	Medium
48.	*Leptochloa filiformis* R. & S.	,,	,,
49.	*L. chinensis* Nees.	,,	,,
50.	*Panicum myurus* H.B.K.	,,	Low
51.	*Paspilidium scrobiculatum* (L.) Stapf. (=*Paspalum scrobiculatum* L.)	,,	High
52.	*Polytocha barbata* Slapt.	,,	High-Medium
53.	*Ottelia alismoides* Pers.	Hydrocharidaceæ	Medium-Low
54.	*Aponogeton natans* Engl. & Kr.	Naiadaceæ	Medium
55.	*Eichornia crassipes* Solms.	Pontedariaceæ	Low
56.	*Monocharia vaginalis* Presl. var. *plantaginea* Solms—Laubach.	,,	Medium-Low
57.	*Typha* spp.	Typhaceæ	Low

DISCUSSION

The specimens when systematically classified show that the dicotyledonous families are almost double in number than the families belonging to the monocotyledonous group, and the monocotyledonous families—Cyperaceæ and Graminaceæ predominate over all other families which are represented by a number of plant species. That the number of the families belonging to dicotyledons are more than that of monocotyledons and that the families Cyperaceæ and Graminaceæ predominate over all other families in having a large number of plant species have also been observed by Chakrabarty (*loc. cit.*). Graminaceous and Cyperaceous species are more in number on medium and low lands than they are found on high lands. The dicotyledonous genera are almost equal to the number of the monocotyledonous genera represented, whereas the monocotyledonous species are more than that of the dicotyledonous ones. Production of large number of seeds which are light in weight and easily dispersed both by water and air might be the probable causes for the preponderance of the monocotyledonous

species, specially the plants belonging to the families Cyperaceæ and Graminaceæ, over the dicotyledonous species although the dicotyledonous genera are almost equal to that of moncotyledonous genera and the dicotyledonous families are more than the monocotyledonous families.

Out of a number of weeds observed by Prain (*loc. cit.*) and Chakrabarty (*loc. cit.*) only nine and seventeen plant species respectively have been found to be common with them separately in the present investigation but when all the three results were compared together then only four weed species were observed by all the three investigators. The rest of the species recorded by the earlier workers have not been observed and in place new species have been found to replace them.

The preponderance of Cyperaceous and Graminaceous weed species, their prevalence in medium and low lands, the elimination of some species with the establishment of some new ones and the persistent presence of some of the weed species support the view-point expressed by Robins *et al.* (1952). They stated that the number of weeds that are present and are growing along with a crop depends mainly on the competition offered by the crop. The competing ability of the weeds, in turn, depends upon the habit, seed germination, growth rate and root system. Ecological studies of the weeds, observed in the present investigation, may, therefore, be helpful in understanding the occurrence of various species, their number, distribution and elimination in course of time.

Summary

Fifty-seven weed species have been recorded of which Cyperaceous and Graminaceous species predominate over all others. Some of the weed species were eliminated in time and are being replaced by others. Occurrence of various weed species, their number, distribution and elimination may be understood if their ecological conditions are studied in detail.

Acknowledgements

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A FURTHER CONTRIBUTION TO THE STRUCTURE AND AFFINITIES OF *CYCLANTHODENDRON SAHNII* FROM THE DECCAN INTERTRAPPEAN SERIES OF INDIA

By C. G. K. Ramanujam

Department of Botany, Andhra University, Waltair

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Introduction

Fossil remains of Cyclanthaceæ have been described under the name *Cyclanthodendron sahnii* (Sahni and Surange, 1944 *a*, 1944 *b*, 1953), from the Deccan Intertrappean beds of India. We know to a considerable extent the morphology and anatomy of the stem, leaf, leaf-sheath and roots of *Cyclanthodendron*, the remains of which occur fairly commonly in the Intertrappean cherts at Mohgaonkalan. Most of the specimens at this locality show beautiful preservation. While examining the serial sections of a fairly well-preserved silicification of *Cyclanthodendron* from Mohgaonkalan the author noticed that the structural details of the vegetative organs like stem and leaf-sheath not only showed some variations but also a few new interesting features which have not been reported in the original paper on *C. sahnii* (Sahni and Surange, 1953).

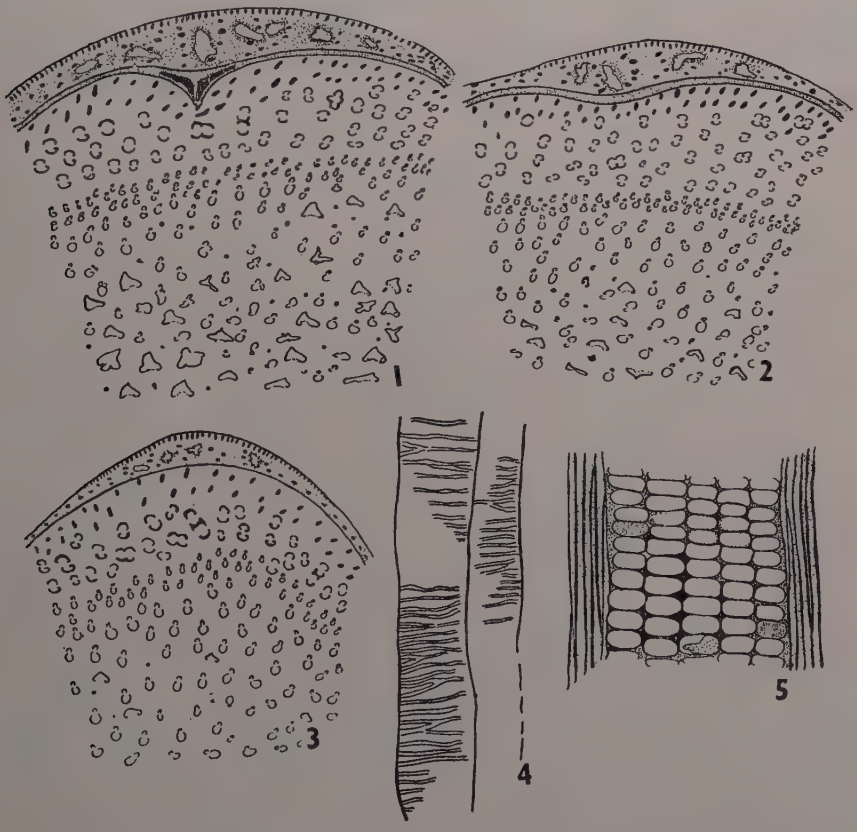
The clumped habit of *Cyclanthodendron* stem so clearly seen in *C. sahnii* is not quite evident in our fossil as the basal portion of the stem is not preserved. It is probable that the fossil stem represents a region somewhat higher up from the base of the original stem, hence no traces of roots have been seen in the present material. Serial sections were made from a specimen about 18 cm. long. There are two stems preserved side by side with the leaf-sheaths in between (Pl. V, Fig. 1) and both of them are incomplete, but represent almost the halves of the original stems.

Description

Stem.—Only the aerial portions of the stem are available in the fossil specimen. The outline of the stem in cross section shows a fine notch at one end (Text-Fig. 6). The stem consists of cortex, dermal, sub-dermal and central regions.

The epidermis, which was not clear in the holotype, is single-layered. The epidermal cells are thick-walled, closely packed and somewhat prismatic (Text-Fig. 7); they are either empty or plugged with some dark contents.

Just beneath the epidermis the cortex, which is quite thin, consists of one to two or at places even three alternating rows of fibrous plates which are oval to rounded. Around the notch they are flattened and tangentially stretched (Pl. V, Fig. 2; Text-Fig. 6). The number of fibres per plate varies to a great extent. Depending upon the size of the fibrous plate the number varies from 8–55 fibres (Text-Fig. 7). As a rule, the fibrous plates immediately beneath the epidermis are bigger than those situated further interior; however, at a number of places the situation is just the opposite. There are no stegmata around the fibrous plates. None of the fibrous plates possesses any trace of vascular elements although in the original specimen some of them have been reported (Sahni and Surange, 1953).



TEXT-FIGS. 1–5. *Cyclanthodendron sahnii* Sahni and Surange. Figs. 1–3. Semi-diagrammatic cross-sections of the stem from various regions to show the nature and distribution of the fibrovascular bundles (1, from the lower part, 2 from the middle part and 3, from the upper part of the fossil specimen). ×about 5. Fig. 4. Scalariform pittings on the metaxylem vessels, ×275. Fig. 5. Longitudinal section to show the nature and arrangement of the ground parenchyma cells from the central zone, ×85.

The thin-walled, rounded to oval parenchymatous cells of the ground tissue are often filled up with some dark contents. In this loose ground tissue are situated the fibrovascular bundles smaller towards

TEXT-FIGS. 6–15. *Cyclanthodendron sahnii* Sahni and Surange. Fig. 6. Outer region of the stem to show the notch and the hypodermal fibrous plates, × 40. Fig. 7. A part of the above enlarged to show the epidermal cells and a fibrous plate, ×275. Fig. 8. A part of the cortex showing the fibrovascular bundles and the ground tissue, ×40. Figs. 9–12. Compound bundles (fused bundles) from the cortex, ×40. Fig. 13. A part of the dermal and sub-dermal regions, ×40. Fig. 14. A part of the sub-dermal region, ×40. Fig. 15. A part of the central region, ×40. *D*, diminutive bundles.

the periphery and towards the interior while bigger in the middle. Besides these bundles, there are a few irregularly oriented cavities, which might represent the air cavities (Pl. V, Fig. 3).

A typical cortical bundle consists of a row of xylem vessels, phloem, xylem parenchyma and two massive sclerenchymatous sheaths (Pl. V, Fig. 3; Text-Fig. 8). In smaller bundles there is only a single large metaxylem vessel and the ventral fibrous sheath is larger and better developed than the dorsal sheath. In the larger bundles, however, the xylem consists of 2–4 metaxylem elements and a few protoxylem vessels, xylem parenchyma and both the dorsal and ventral sheaths are equally well developed and crescent-shaped. The phloem is generally seen in disorganized condition. However, when fairly preserved, it is found to consist of small angular, thin-walled, closely packed, hyaline cells. The parenchymatous cells separating the dorsal and ventral sheaths of the vascular bundles are sharply demarcated, small, round to oval and arranged in a horizontal row. No structures comparable to stegmata in association with the sclerenchyma sheath of the vascular bundles have been observed in the present specimen.

Some big bundles formed apparently by the fusion of 2–4 cortical bundles are present locally in the cortex. The evidence at hand points out that the presence of such compound bundles is a uniform feature throughout the length of the stem. The bundles in the cortex are generally spaced fairly widely and at few places where they are placed proximal to each other they invariably engage in fusion forming the compound bundles. We do not know for certain the significance of these fused bundles. It is possible that these bundles provide additional strength and rigidity to the leaf-sheath which after all is formed from the cortex itself.

The compound bundles in the cortex are formed by the fusion of 2–4 discrete bundles situated in close proximity to each other (Pl. V, Figs. 3, 4; Text-Figs. 9–12). The bizare shapes of these bundles are due to various types of fusion. When two bundles fuse, fusion is usually manifested along their sides, but often they also fuse end to end (*i.e.*, the ventral sheath of one bundle fuses with the dorsal sheath of another bundle). In Text-Fig. 11 is shown a compound bundle resulting from the fusion of three vascular bundles. Here probably lateral fusion took place between two bundles at first. Later on, one of these fused with a third bundle end to end. Frequently three discrete bundles fuse with each other end to end to form a gigantic structure. And lastly, rather sporadically, we also come across a few grotesque bundles formed by the fusion of four bundles; the fusion in this case also taking place along their sclerenchyma sheaths.

Next to the cortex is a very narrow dermal zone constituted by one or two tangential rows of fibrous bundles. The bundles are small, closely packed, collateral and normally oriented, *viz.*, they have their long axes parallel to the radial plane of the stem (Pl. V, Fig. 3; Text-Fig. 31). They are placed about 2–4 cells apart and possess a dorso-ventral sclerenchymatous sheath. The dorsal sheath of the bundles

is uniformly very scantily developed as against the better developed ventral sheath; the former is in the form of a small crescent patch while the latter is sickle-shaped. In a few extreme cases the dorsal sheath is very thin and only one or two cells thick. The two sheaths are separated from each other by a narrow often badly preserved strip of parenchyma cells. In some of the outermost bundles, however, the dorsal and ventral sheaths fuse together forming a continuous oval to oblong dermal bundle. The vascular elements of the dermal bundles are poorly developed; the xylem consists of a single metaxylem vessel and one or two protoxylem elements. The phloem is not preserved.

The transition from the dermal to sub-dermal zone is rather abrupt. The latter, however, is more generously developed in the fossil stem.

The sub-dermal zone (Pl. V, Figs. 3, 5; Text-Fig. 14) consists of numerous fibrovascular bundles of different sizes; all the gradations between the small and those that can be seen with the unaided eye are found dispersed in this region rather promiscuously. The vascular bundles which are very minute and of a very simple construction are designated here as diminutive bundles for descriptive purposes. There are no concentric bundles in this zone.

The orientation of the fibrovascular bundles in the sub-dermal zone is irregular; some are parallel to the radial plane of the stem while others are obliquely disposed. The vascular bundles in this zone can be conveniently grouped under three types, *viz.*, the diminutive bundles, the normal collateral bundles of diverse sizes and lastly the apparently compound bundles (lobed bundles) of gigantic dimensions.

The diminutive bundles, so called because of their very minute size (they are smaller than the smallest of the collateral bundles) are rather sparse and scattered irregularly in the general ground tissue. Their organization is very simple; in the majority of cases they possess a single extremely small xylem vessel, circumscribed by a few sclerenchymatous cells (Pl. V, Figs. 5, 7; Text-Fig. 15). Phloem is not seen in any of these bundles. The origin and significance of these bundles is dealt with in the description of the central zone.

The bulk of the vascular bundles in the sub-dermal zone are of the normal collateral type. They are of various sizes but in general bigger than the dermal bundles. As in the dermal zone, here also the dorsal and ventral sheaths are unequally developed; the former is in the form of a meagrely developed crescent patch, while the latter is represented by a thick sickle-shaped patch. There is, however, one difference, *viz.*, the walls of the individual fibres constituting the dorsoventral sheath in the dermal bundles are very much thickened, whereas in the sub-dermal bundles the walls of the sheath cells are not so thick. The organization of the vascular elements in the sub-dermal bundles is similar to that of the dermal bundles.

In addition to the above described bundles the sub-dermal zone also possesses a few uncommonly large bundles. These are seemingly

compound in nature. Text-Fig. 16 and (Pl. V, Fig. 6) clearly bring home the nature and organization of these bundles. These are the lobed bundles described in the original specimen by Sahni and Surange (1953). They are fusiform and give rise usually to a single median branch. The compound nature of the bundle is due to the fact that its daughter strand instead of getting separated is found clinging on to its dorsal side. In almost all the cases the lobed bundles of the sub-dermal zone possess a single daughter strand attached to them. The ventral and dorsal sheaths of these bundles are either separate or united and equally developed, but in general they are narrow consisting of only 1–3 layers of moderately thick-walled sclerenchyma cells. The ventral arc of the sclerenchymatous sheath is either smoothly hemispherical or often shows a definite bay-like depression. The xylem elements are loosely arranged in a semicircular manner with many round to oval wood parenchyma cells in between. The protoxylem elements are embedded deep into the ventral arc with usually two layers of radiating parenchyma cells around them.

The bundles in the central zone are apparently more closely placed and of three types as in the preceding zone, *viz.*, the normal collateral bundles irregularly disposed and of various dimensions, the gigantic lobed bundles and the diffuse diminutive bundles (Pl. V, Fig. 7).

The structural details of the collateral bundles and the diminutive bundles are similar to those of the sub-dermal zone. The diminutive bundles, however, are more commonly found in the central region (Pl. V, Fig. 7).

The lobed bundles are also similar to the corresponding structures in the preceding zone, but are more common here and usually consist of 1–2 daughter strands (Text-Figs. 17, 18). Usually at any given level up to a certain extent the frequency of the lobed bundles in the central zone is always higher than in the sub-dermal. The distribution and the frequency of the lobed bundles vary according to the level of the stem from where the sections are made. When the course of the lobed bundles is followed in our fossil stem which is about 18 cm. long it is found, that their frequency is quite high at one end (representing the lower part) and low at the other end (representing the upper part); as a matter of fact the number of lobed bundles gradually but perceptibly decreases from the base toward the top of the stem (Text-Figs. 1–3).

When a lobed bundle in the central region branches it cuts off from one end of the arc small collateral bundles one or two at each time. The daughter bundles possess both dorsal and ventral sheaths and are in organic connection with the parent strand for some distance before getting separated. Even after separation these bundles run straight upwards, parallel to the parent bundle for at least some distance and then gradually deviate from the latter at a wide angle. It may be mentioned that no lobed bundle appears the same in a transverse section at different levels; it changes in its shape and size and sometimes in the number of its daughter strands. Lobed bundles with more than two daughter strands are not seen in the fossil material.

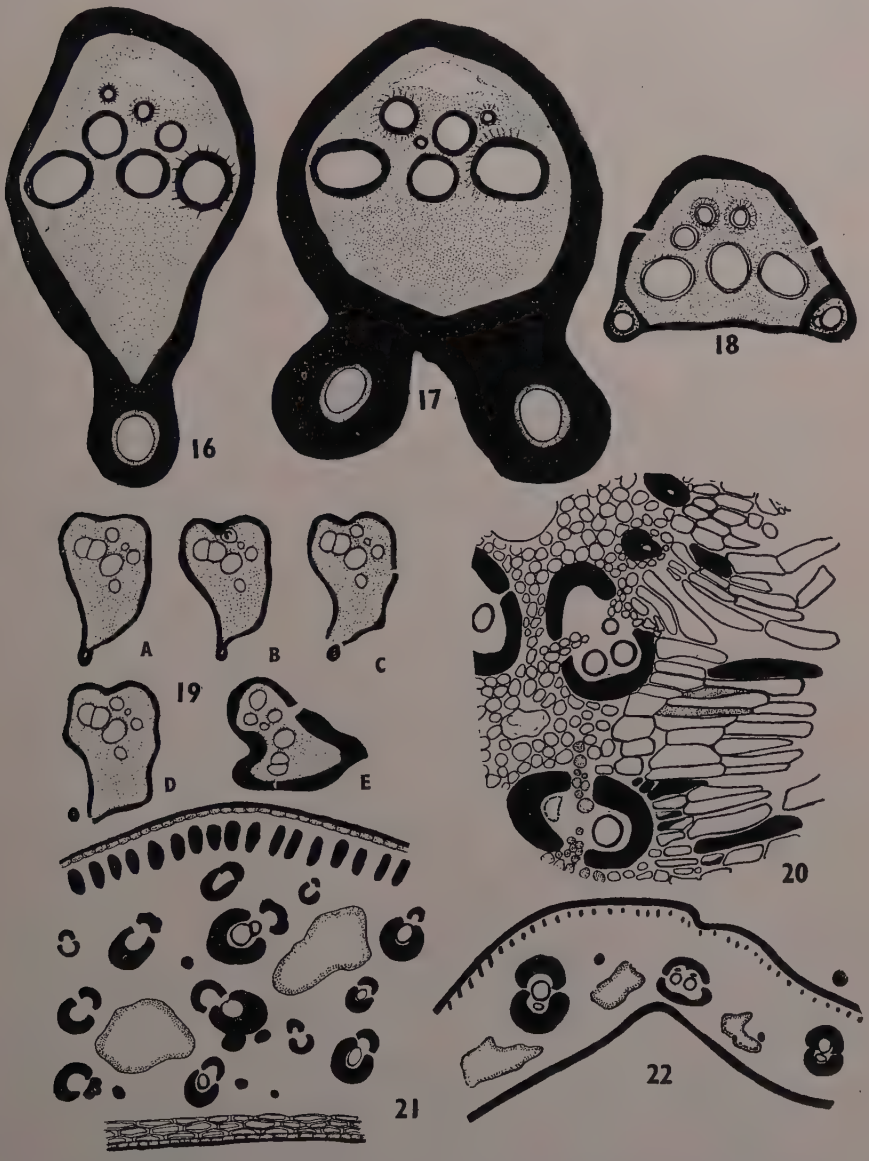
After the daughter bundles are separated the parent strand moves ahead probably cutting off another set of bundles.

Nature and origin of the diminutive bundles can be understood by a careful study of the various serial sections. By and large it is found from the evidence at hand that these minute and extremely simple bundles seen commonly in the central zone are given off by the gigantic lobed bundles (Text-Fig. 19 A-E). They are always given off from the dorsal arc of the lobed bundle, and probably immediately after they are formed they get separated from the main strand and then run parallel to the latter for some time before deviating to its left or right at an acute angle. The frequency of the diminutive bundles obviously is directly proportional to that of the lobed bundles; concomitantly the number of these bundles gradually falls down as we go from the base toward the distal part of the stem. In case the diminutive bundles fail to sever from the main strand they may gradually increase in size, becoming fully organized meanwhile and resemble the normal collateral bundles found throughout the stem. And probably at a later time, these daughter strands are cut off from the parent bundle. From the mode of the origin of the diminutive bundles, it becomes increasingly evident that they represent the miniature fibrovascular bundles, in which the normal development of the vascular elements and the sclerenchyma sheath has been arrested at a very early stage, probably due to their precocious separation from the parent strand. As the stem could not be traced further still upwards we do not know the ultimate destiny of these bundles.

None of the sub-dermal or central fibrovascular bundles possess stegmata. The protoxylem elements show spiral thickenings and the sculpturing of the metaxylem vessels is of the scalariform type; the scalariform bars are either simple or branched (Text-Fig. 4). The perforations of the vessels are inclined and simple but occasionally scalariform with 5–10 moderately thick, simple or branched bars. No pits are seen on the sclerenchymatous cells of the sheath.

The ground tissue consists of loosely arranged rounded to oval large parenchyma cells enclosing numerous air-spaces (Pl. VI, Fig. 9). At the dermal zone, however, the parenchyma cells are small and compactly placed probably due to the very limited space between the closely distributed vascular bundles. The closely packed nature of the parenchyma cells coupled with the densely distributed vascular bundles facilitate the dermal region easy to locate despite the fact that this zone is very narrow and ill-developed compared to the other zones. In thick sections the parenchyma cells are found overlapping one another. The cells adjacent to the bundles are more or less elongated and aligned in a radiating manner. This radiating pattern of the parenchyma is however, seldom more than one cell thick. In tangential sections the parenchyma cells are rectangular with rounded corners and aligned one above the other in longitudinal seriations (Text-Fig. 5). Often these cells are filled up with a dark deposit.

In Pl. V, Fig. 8 and Text-Fig. 20 is shown a wounded region from the sub-dermal zone of the stem. No trace of any destructive agent



TEXT-FIGS. 16–22. *Cyclanthodendron sahnii* Sahni and Surange. Fig. 16. A compound bundle from the sub-dermal region, ×85. Figs. 17, 18. Compound bundles from the central zone, ×85. Fig. 19. A-E formation of diminutive bundles from a lobed bundle, ×40. Fig. 20. Wounded region from the sub-dermal zone, ×40. Fig. 21. A part of the cross-section of a leaf-sheath, ×40. Fig. 22. Cross-section of a leaf-sheath showing a single median row of normally oriented vascular bundles, ×40.

has been seen here. In the centre is seen a cavity, the ground parenchyma cells surrounding this cavity seem to have undergone profuse proliferation. These cells are very much elongated and apparently aligned in a radiating manner. The walls of these cells are greatly thickened.

Leaf-sheath.—The stem proper is covered by a felt of distinctly preserved leaf-sheaths. The leaf-sheaths are almost completely preserved. In a cross-section a leaf-sheath is seen thickest in the middle, gradually thinning out towards the edges which form the flaps (Pl. V, Fig. 1; Pl. VI, Fig. 10; Text-Fig. 3).

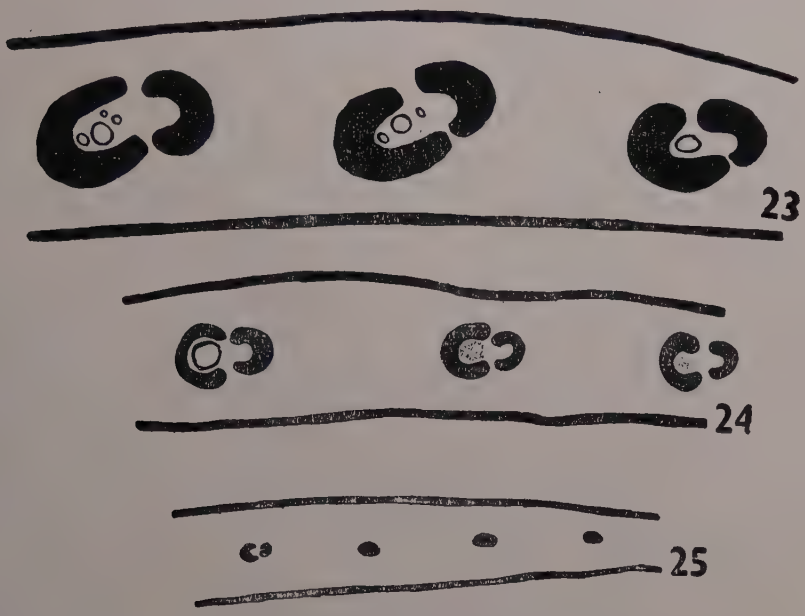
The cells of the outer epidermis are lined by a thick dark layer (cuticular layer ?). The epidermal cells are with angular inner walls and somewhat flattened outer walls. The cells of the lower epidermis are transversely flattened and somewhat barrel-shaped (Text-Fig. 21).

Just below or a few rows of cells away from the upper epidermis are present numerous highly prominent fibrous plates in mostly one but occasionally two rows (Pl. VI, Fig. 13). The fibrous plates of the outer row are bigger and vertically elongated and possess 40–75 thick-walled cells, while those of the lower row (when present) are shorter and smaller possessing only 20–40 cells and placed alternating with the plates of the preceding row. The ground tissue of the leaf-sheath is made up of thin-walled loosely packed rounded to oval parenchymatous cells, many of which are filled with brownish red or dark contents which stand out prominently. Just above the lower epidermis the ground tissue, however, consists of 3–5 rows of tangentially flattened (usually rectangular) closely packed, moderately thick-walled cells (Pl. VI, Fig. 11).

In the broad middle part of the leaf-sheath, the fibrovascular bundles are aligned in many (5–8) somewhat irregular rows; the bundles usually have their long axes vertically placed parallel to the radial plane of the stem (Pl. VI, Figs. 11, 12; Text-Fig. 21). As we scan from the broad middle part toward the edges of the leaf-sheath the number of the vertical chains of bundles gradually decreases and ultimately the bundles come to lie in a single transverse seriation always distinctly seen. The hypodermal fibrous plates disappear; further, the orientation of the bundles also undergoes appreciable change, as there seems to be a rotation of the bundles by about 90° (Pl. VI, Fig. 14). The long axes of these bundles are now parallel with the leaf-sheath epidermis and at the extreme edges of the sheath the fibrovascular bundles seem to have been replaced by small rounded to elliptical fibrous plates (Text-Figs. 22–25). It may be mentioned here that a few small fibrous plates are always found here and there throughout the general ground tissue of the leaf-sheaths.

The fibrovascular bundles of the leaf-sheath are, as a rule, simple and collateral and consist of xylem, phloem, dorsal and ventral sclerenchymatous sheaths. Their structure is practically the same as that of the cortical bundles. Here and there are present a few compound

bundles formed by the fusion of 2–3 fibrovascular bundles along their sides or end to end.



TEXT-FIGS. 23–25. *Cyclanthodendron sahnii* Sahni and Surange. Fig. 23. Cross-section from another region of the leaf-sheath showing the obliquely oriented vascular bundles, ×40. Fig. 24. Cross-section nearer the edge of the leaf-sheath showing the transversely oriented vascular bundles, ×40. Fig. 25. Cross-section from the extreme edge of the leaf-sheath showing a few centrally placed fibrous plates, ×40.

In some cases the leaf-sheaths contain many wounded regions marked by the disorganization of the tissues. A closer examination has revealed the presence of a rather poorly preserved pathogenic fungus in these wounded parts. The mycelium of the fungus consists of a loosely woven network of septate (?) hyphæ. The individual cells of the hypha are very thick-walled and dirty brown in colour. Apparently arising from the sides of some of these cells are seen small piliferous structures with a short stalk ending in a rounded head, which might represent some spore-like structures. The cells of the ground parenchyma at the wounded patches have greatly thickened walls and filled up with some dark contents. It has not been possible to identify the fungus owing to its imperfect preservation.

None of the many sections prepared by the author showed those conspicuous air cavities strictly in two rows as in the original specimen of *Cyclanthodendron sahnii*. On the other hand, a single highly irregular row of air cavities of diverse sizes and shapes is found in the widest part of the leaf-sheath. On the whole the air cavities and the vascular

bundles together do not show any regular and definite arrangement as is usually expected in *Cyclanthodendron sahnii* (Pl. VI, Fig. 12; Text-Figs. 21–22). The fact that the leaf-sheaths are fairly well preserved indicates that preservation has got nothing to do with this state of affairs.

Discussion

When compared with *Cyclanthodendron sahnii* described by Sahni and Surange (1953) our specimen shows some important variations, which probably are due to the fact that it represents a different and somewhat higher region of the stem. Besides variations, there are also a few additional features present in this fossil and not previously described in the holotype.

The fibrovascular bundles from all the regions of the stem and leaf-sheaths of *C. sahnii* described by Sahni and Surange possessed distinct stegmata. But in the present fossil no such structures have been observed even once. Both longitudinal and transverse sections have been carefully examined for these structures, but without any result. Even in the recent species of *Cyclanthus* and *Carludovica* stegmatal cells are not always present, hence their absence in the present fossil need not surprise us. On the other hand, it is also possible that as the present fossil represents a higher region of the stem, it might be that the stegmata are absent from this region of the stem. Sahni and Surange (*loc. cit.*) have described that the fused bundles in the cortex of *C. sahnii* are formed by the fusion of two bundles along their sides, but from the new specimen it can be gathered that the fusion between the cortical bundles is more varied and relatively more complex and that more or less similarly fused bundles can also be expected in the leaf-sheaths.

The organization of the dermal, sub-dermal and central bundles in the present specimen is more or less similar to that of the corresponding structures in the holotype. However, in the original specimen a few concentric bundles have been found in the sub-dermal region which are conspicuous by their absence in our material. In the original specimen of *C. sahnii* the metaxylem vessels show multiseriate reticulate type of pitting and simple perforations, while in our specimen the metaxylem vessels possess scalariform pitting and the perforations are either simple or occasionally scalariform and inclined. Further the so-called diminutive bundles seen in the present fossil have not been described in the original specimen. From the excellent photographs given by Sahni and Surange (*loc. cit.*) it becomes evident that such bundles were probably not present in that particular fossil described by them; or could it be that these minute structures have somehow escaped their attention?

The leaf-sheaths of *Cyclanthodendron sahnii* possess two median rows of large air canals with the vascular bundles in vertical rows in between them. Such a definite arrangement of air canals and of the vascular bundles is not found in the fossil under investigation; there is,

however, a single irregular row of air cavities in the present specimen. This may be due to the fact that the present specimen represents a different region of the stem. In Sahni and Surange's (1953) paper in Plate V, Fig. 3, which represents a cross-section of the stem at the upper end there are no distinct transverse seriations of large air canals with the bundles between them. From this one may safely conclude that the two regular median rows of air canals with the vascular bundles between them do not form such a prominent feature of the leaf-sheaths at the upper regions of the stem. And lastly differentiation in the orientation of the vascular bundles from the centre toward the edges of the leaf-sheaths so distinctly seen in our fossil specimen has not been described in the holotype.

Recently Mrs. Chitaley (1956) while investigating the fructification of *Tricoccites trigonum* has described the presence of several ensheathing leaves. Unfortunately no organic connection between the tissues of these fruits and the sheaths has been found. Still, it is interesting to note that there are some striking resemblances between these leaf-sheaths and those of *Cyclanthodendron sahnii*, which have already been mentioned by Chitaley. She, however, found some differences in the absence of stegmata and the somewhat irregular arrangement of the vascular bundles and the air cavities. Incidentally a comparison of the former with the leaf-sheaths described in the present specimen of *Cyclanthodendron sahnii* indicates a closer agreement between the ensheathing leaves found in intimate association with *Tricoccites trigonum* and those of *C. sahnii*. This is evidenced by the fact that besides other similarities, there is also agreement in the somewhat irregular arrangement of the vascular bundles and the air cavities (which are found in a single irregular row) and the absence of stegmata around the fibrovascular bundles. And if it is proved that the ensheathing leaves of the fructifications of *Tricoccites trigonum* actually belonged to them, it will then have an added significance in view of the above findings.

The common occurrence of the remains of *Cyclanthodendron* in the Eocene of India indicates that the family Cyclanthaceæ might have enjoyed a fairly important representation in the Indian Intertrappean flora. Investigations on the Tertiary flora of India are rather limited as against the exhaustive amount of work done on the Jurassic vegetation. A prolonged and extensive work on the Intertrappean series would be of immense utility in unravelling the luxuriant early Tertiary flora of India. The link between the contemporary flora of South America and the Eocene vegetation of India exemplified by the occurrence of fossil remains of Cyclanthaceæ and *Rodeites* (a fossil sporocarp resembling the South American genus *Regnellidium*—Sahni, 1943) may further be augmented by the discovery of other elements common to both the floras. Although it would undoubtedly be too much basing on these discoveries to put forward any positive opinion about the trends of migration of these elements, one could, however, understand that the groups concerned have every appearance of being strongly reduced and possibly may once have had a wider and greater distribution in the

tropics. As regards the remains of Cyclanthaceæ it is very likely that future pursuits may throw greater light on the bygone history of this interesting family in this sub-continent.

Summary

A new fossil specimen of *Cyclanthodendron sahnii*, representing probably a higher region of the aerial stem, has been described from the Mohgaonkalan beds of the Deccan Intertrappean series of India. Besides possessing a few additional characters it also shows some variations from that of the original type specimen, which are probably due to its representing a different region of the stem than that of the latter.

Acknowledgements

The author is grateful to Prof. J. Venkateswarlu for his kind interest and encouragement. To the Government of India the author is thankful for the award of a National Research Fellowship.

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Explanation of Plates

Plate I

Figs. 1–8. *Cyclanthodendron sahnii* Sahni and Surange

Fig. 1. A cross-section at the basal part of the fossil specimen. Note the leaf-sheaths and the stems, $\times\frac{3}{4}$ nat. size.

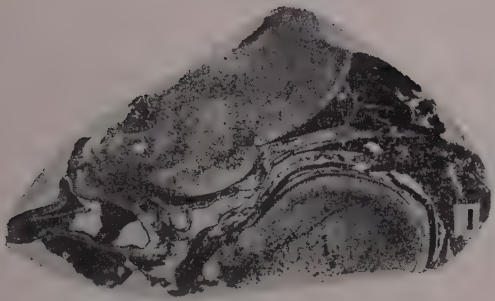
Fig. 2. A part of the cross-section of the stem showing the leaf-sheaths and the hypodermal fibrous plates, ×25.

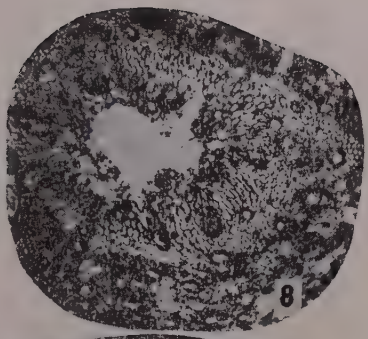
Fig. 3. A part of the cross-section of the stem showing the cortex, dermal and sub-dermal regions, ×25.

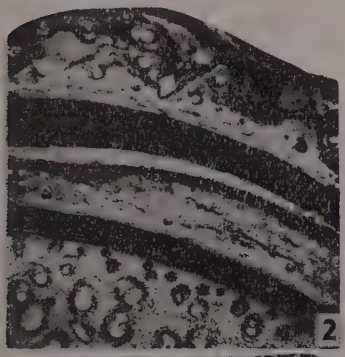
Fig. 4. A part of the cross-section of the stem showing the cortex and the dermal zones. Note the cavities in the cortex, ×25.

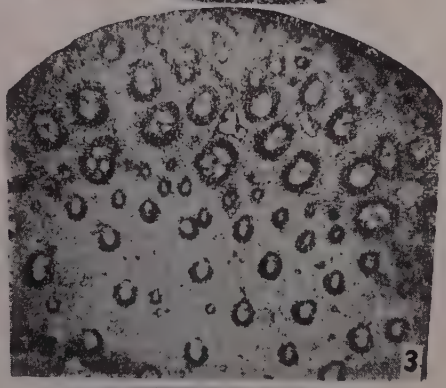
Fig. 5. A part of the cross-section of the stem showing the diminutive bundles in the sub-dermal region, ×33.

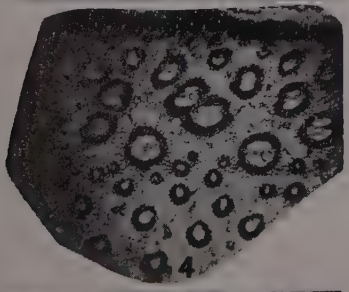
Fig. 6. A part of the sub-dermal region with a lobed bundle, ×55.

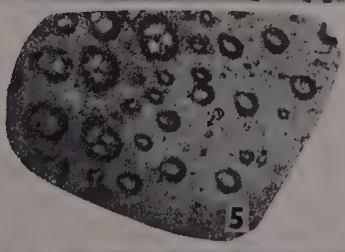


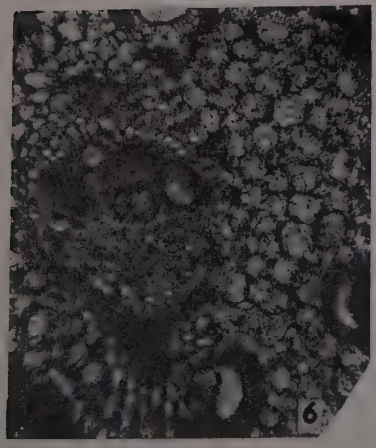


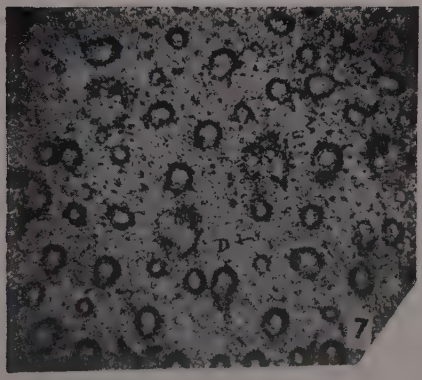




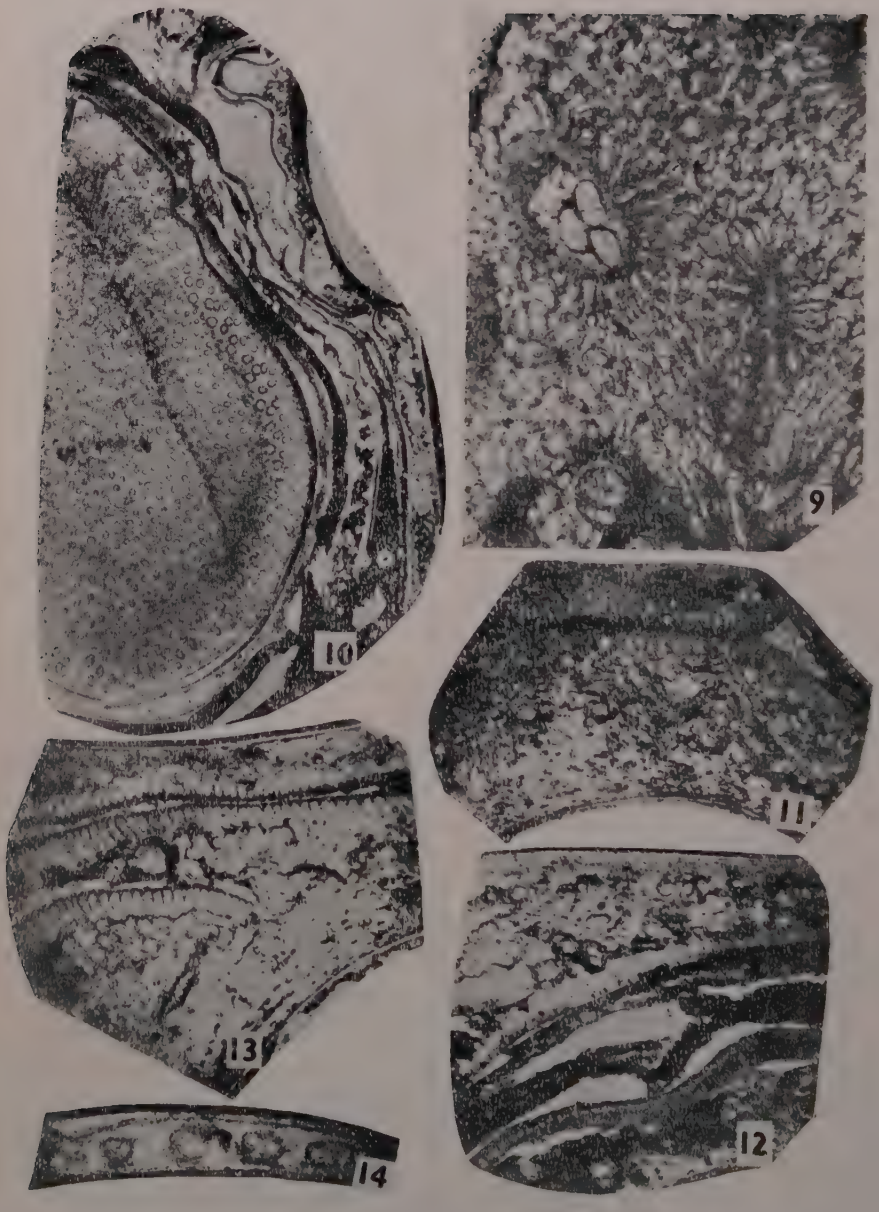








C. G. K. Ramanujam FIGS. 1–8



C. G. K. Ramanujam

FIGS. 9–14

FIG. 7. Fibrovascular bundles (simple and lobed) and the ground tissue from the central zone. *D*, diminutive bundles, ×33.

FIG. 8. A part of the wounded region from the sub-dermal zone of the stem, ×25.

PLATE VI

FIGS. 9–14. *Cyclanthodendron sanhii* Sahni and Surange

FIG. 9. A part of the central zone showing the nature of the ground parenchyma. Note the radiating pattern of the parenchyma cells around the vascular bundles, ×55.

FIG. 10. Cross-section of one of the stems and a few leaf-sheaths, from the upper region of the fossil specimen. Note the irregular air cavities in the leaf-sheaths. Approx., ×2½.

FIGS. 11, 12. Cross sections of the leaf-sheaths at their middle regions. Note the irregular air cavities, nature of the ground parenchyma and the vascular bundles, ×45.

FIG. 13. A part of the cross-section from another leaf-sheath. Note the distinct hypodermal fibrous plates, ×45.

FIG. 14. A part of the cross-section from the edge of a leaf-sheath showing the transversely oriented fibrovascular bundles, ×65.

A CONTRIBUTION TO THE STUDY OF AMARANTHACEÆ

Telanthera ficoidea Moq.

By G. P. Shrivastava

Botany Department, Siddharth College, Bombay-1

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Introduction

The present work is intended as a further contribution to the study of Amaranthaceæ. Amaranthaceæ and Chenopodiaceæ are two large, world-wide families, showing a close relationship in their external and internal morphology. As regards their systematic positions in plant kingdom, most authors notably Bentham and Hooker (1862) have grouped them with such families as Nyctaginaceæ, Phytolacaceæ and Caryophyllaceæ, under a common order Centrospermæ. Hutchinson (1926) on the other hand splits these various families into three different orders, *viz.*, Caryophyllales, Chenopodiales and Thymelæales.

The study of Amaranthaceæ partly on account of anomalous secondary growth in the central cylinder and partly because of having extra vascular bundles in the medulla, has received a great deal of attention from Botanists as evidenced from the researches of De Bary (1884), Morot (1885), Solereder (1908), Haberlandt (1914), Wilson (1924), Dastur (1925), Joshi (1931), Maheshwari (1941), Metcalfe and Chalk (1950), Vishnu Mittre (1955) and others too numerous to be reviewed here.

The study of several species belonging to the genus *Alternanthera* has been already completed by a number of previous workers, *viz.*, *A. spinosa* (Schleiden and De Bary, 1877); *A. procumbens* (Nemnicha, 1894); *A. muscoides* (Solereder, 1908); *A. aquatica* (Chodat and Rehfous, 1924); *A. sessilis* (Joshi, 1931); *A. triandra* (D'Almeida, 1942); *A. philoxeroides* (Metcalfe and Chalk, 1950); *A. polygonoides* (Shrivastava-Santapau, 1952); *A. repens* (Vishnu Mittre, 1955). The study of *Telanthera ficoidea* affords good scope for a comparison with that of *Alternanthera sessilis* and *A. repens*. The plant also shows a valuable medicinal property which will go further to enrich the importance of family Amaranthaceæ.

Material and Methods

The material for the present work was obtained locally from Bombay and Salsette Islands, which contain a fairly representative number of Indian and exotic Amaranthaceæ. The observations have been made from free-hand sections stained with safranin and Orange G,

in clove oil, mounted in Canada balsam or stained with safranin and mounted in glycerine.

External Morphology

Telanthera ficoidea is an annual-perennial herb, partly procumbent. Axis is rectangular or partly flat, ridged or fluted, the ridges running parallel to each other, covered with small shining white hairs all along the surface. Nodes and internodes are prominent pinkish violet in colour. Branches are many, slender, opposite, ascending or drooping. Leaves are simple, opposite, sometimes alternate, crimson or greenish-violet, $4 \cdot 5 \times 1 \cdot 5$ to $2 \cdot 5$ cm. long, membranous or somewhat leathery, hairy on both the surfaces, elliptic, acute, shortly petiolate and decurrent. The normal phyllotaxy is opposite and decussate. The specimens with alternate leaves show 1/5 phyllotaxy. Petioles short, grooved, hairy all over the surface.

Flowering period is from March–May. Inflorescence both axillary and terminal, 1–$2 \cdot 5$ cm. long. The terminal spikes arise in bunches of 4 to 5, the central being the largest. Flowers spirally arranged on the peduncle axis, bisexual, regular, bracteate; bract 1, bracteoles 2, are more or less equal in length, though minute, linear to lanceolate, entire, acute, pink tipped, hairy. Hairs are long multicellular 4-celled, colourless with distinct joints, pointed tips and thickened walls. Perianth lobes are 5 in number whitish with a pinkish tinge, lanceolate, entire, acute, quinquncial æstivation. Stamens are 5, opposite to the perianth lobes; filaments transparent, massive, connate at the base surrounding the ovary; anthers are yellow, small, 1-celled and versatile. Pollen grains are small, rounded, smooth-walled. The outer and inner walls are distinct, the former somewhat brownish. Ovary is superior, globular, compressed, green with a single, short, greenish-white style and 2 capitate yellow stigmas. Ovule is pendulous and white. Fruit is a circumcissile capsule with one yellowish brown seed.

Medicinal Importance

The herb is held in high esteem as a remedy for "weeping eczema". Dr. H. P. Shrivastava, M.B.B.S., of Bombay has treated more than 150 people suffering from the above disease, which appears either near the ankles or below the knees. The fresh juice of young leaves extracted in water and applied on "weeping spots" for three to seven days stops the oozing of water and the burning sensation. Later on the skin becomes soft and changes its colour. The patients suffering from this disease are prohibited to take eggs or fish but can take mutton. The "weeping wounds" should be washed daily before applying the solution with "gram flour", not with soaps.

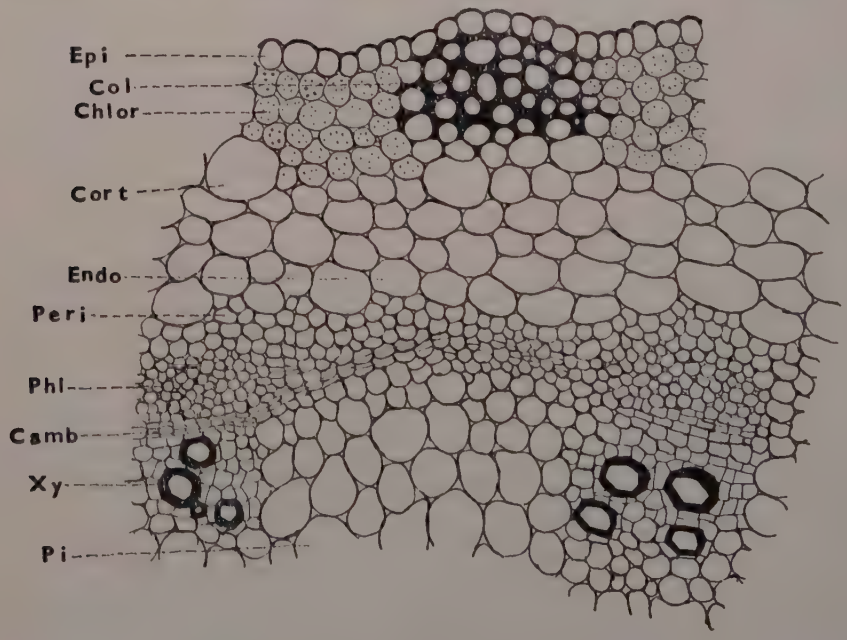
Distribution and Habitat

The plant is a member of Brazilian flora, but commonly cultivated in tropical gardens. Usually the plant is grown for ornamental purposes. It is also known as *Alternanthera amabilis*. The plant is propagated by cuttings. It grows very well in soft, rich humus soil.

Internal Morphology

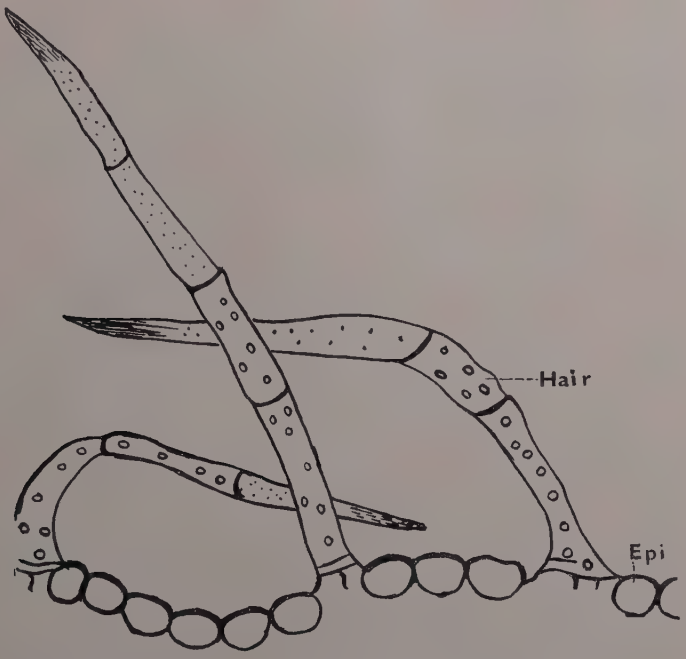
Transverse section of a young stem of *Telanthera* shows a number of shallow ridges and furrows. The epidermis consists of small, partly thick-walled cells, with a thick cuticle on the outer side. The lateral and the inner walls of the epidermal cells are thin. The epidermal hairs are multicellular, long, tapering from a broad base, situated at the same level as that of the epidermal cells. They are more numerous on the ridges than in the furrows. The epidermis is followed by the underlying cells either chlorenchymatous or collenchymatous arranged alternately in segments or as in some cases the latter enclosed by the former. These well developed zones are followed by a short 2-3 layered cortex composed of elliptical, thin-walled parenchymatous cells, which are compact with few or no green pigments. The last layer of the cortex is differentiated into an endodermis of small elongated cells, though not very prominent but they contain dark violet cell sap. This feature is clearly seen in unstained sections. The pericycle is of smaller thin-walled cells, but as the axis matures it shows lignification only at certain segments. The vascular arrangement is of a normal type.

The primary vascular bundles are collateral, conjoint and open; some of them are well developed. These major vascular bundles are few, but they are arranged in pairs on the same vertical plane. At the centre of the axis there is a well developed pith, made up of larger, rounded or partly isodiametric, thin-walled compact cells. Some of



Text-Fig. 1. T.S. of primary stem, ×155.

them show aggregate crystals of calcium oxalate. The peripheral pith cells are smaller, rounded and contain chlorophyll grains. These cells are thrown up into folds so as to appear somewhat "arched". In *Telanthera ficoidea* there is complete absence of any type of medullary vascular bundles (Text-Figs. 1, 2 and Pl. VII, Fig. 1).



TEXT-FIG. 2. Epidermal hairs, ×105.

DISCUSSION

Telanthera ficoidea presents a number of peculiar characters which are quite different in several respects from the species of the genus *Alternanthera*. In some of these characters it resembles other genera of the family Amaranthaceæ. On the whole, the plant shows a mixed affinity towards *A. sessilis* and *A. polygonoides* on the one hand, and *A. repens* on the other. One of the most important anatomical features in *Telanthera ficoidea* is the absence of medullary or pseudomedullary bundles in the stem axis; this brings the plant near *A. repens*. In other species of *Alternanthera e.g.*, *A. sessilis* and *A. polygonoides*, pseudomedullary bundles are present. Another point of great interest in the anatomy of *Telanthera* is the occurrence of clustered crystals of calcium oxalate. With reference to this Metcalfe and Chalk (1950) say "The type of calcium oxalate which occurs in Amaranthaceæ brings this family more into line with Caryophyllaceæ than with the others which belong to Centrospermæ".

The epidermis forms ridges and furrows in *Telanthera ficoidea* and *A. sessilis* while in *A. repens* it is smooth.

The endodermal and pericycle cells are not well marked, the former contain violet pinkish cell-sap which is not recorded in other species of *Alternanthera*.

The development of chlorenchymatous bands below the epidermis is also a special feature of *Telanthera* which is not seen in *A. repens*.

The pollen grains are small, rounded, and the cavity is full of round, brownish yellowish contents with no visible marks, while the pollen grains in case of *A. sessilis* are minute, rounded, yellowish with pentagonal arches formed in the pollen cavity; and in *A. repens* they are hexagonal in shape with triradiating marks in the cavity.

Another peculiarity observed during the study of the morphology of *Telanthera* is the absence of adventitious roots which are common in *A. sessilis* and *A. repens*.

A few words may also be said about the medicinal property of *Telanthera ficoidea*. As far as my knowledge goes no mention is made in the literature about this property. It seems then reasonable to assume that the medicinal property of *Telanthera* as observed by Dr. H. P. Shrivastava is reported for the first time.

Summary

Telanthera ficoidea shows a number of important external features, *viz.*, poor development of the adventitious roots, presence of whitish hairs in the grooves, fruit a circumsessile capsule. Pollen grains are rounded with yellowish contents with no visible markings in the pollen cavity.

The typical anatomical characters are the complete absence of medullary or pseudomedullary bundles in the stem, and the presence of clusters of calcium oxalate crystals in the pith.

Acknowledgements

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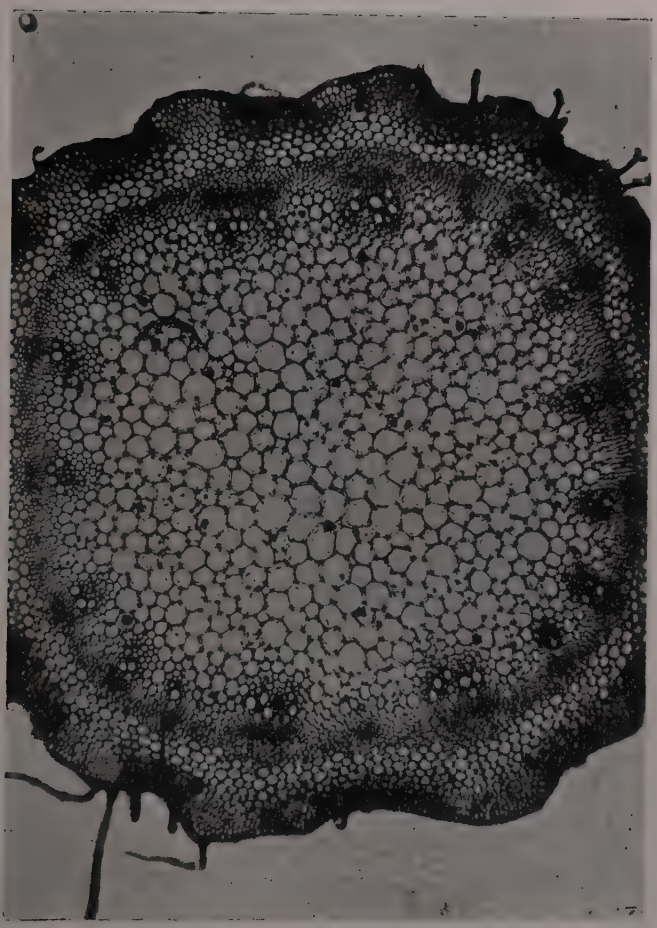

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EXPLANATION OF PLATE VII

FIG. 1. Photomicrograph of T.S. of a primary stem.

CYTOLOGY OF A FEW LOW STERILE PLANTS IN *NICOTIANA TABACUM* L.*

By D. M. Gopinath

Botanist, Cigar and Cheroot Tobacoo Research Station, Vedasandur

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Sterility in crop plants is of common occurrence and it may be due to either physiological, genetic or cytological reasons. In *Nicotiana tabacum* different types of sterility resulting in either a complete or partial failure of seed setting, complete or partial pollen abortion, complete or partial ovule collapse have been reported. Low percentage of pollen sterility was observed in a few strains of *Nicotiana tabacum* (Cigar types) at this Station. This paper embodies the results of a cytological investigation of these low sterile lines.

Varieties *Zimmer Spanish*, *Comstock Spanish*, *Pennsylvania Seed Leaf-Greider*, *Connecticut Broad Leaf* × *Comstock Spanish* and *Havana* 142 comprised the material for this study.

Material for cytological investigation was collected and fixed in 3 parts of 95 per cent. alcohol to 1 part of glacial acetic acid. After 48 hours, the fixative was drained off and the material washed and preserved with 70 per cent. ethyl alcohol. It was stored in a refrigerator to prevent deterioration of the material due to excessive heat. Aceto-carmine smear technique was followed.

In the microsporocyte analysis for any cytological aberration usually the pachytene stage is considered the best because, a detailed study of the pairing of homologous chromosomes, translocations and inversions, if any, supernumerary chromosomes and their relation to the other chromosomes, etc., could well be determined. Unfortunately, very few kinds of material yield themselves for a good pachytene study. Tobacco is one such which does not give good pachytene stages and, therefore, all the observations have to be made in the later stages like diplotene, diakinesis, metaphase, anaphase, etc.

The material under investigation was first analysed for pachytene but, as it was found not to throw any light, was subsequently analysed for the later stages and the observations recorded here mostly pertain to metaphase, early anaphase and telophase. As many samples as were available were analysed.

To get estimates of the percentage pollen abortions, samples consisting of mature buds were collected from all the plants from which samples for cytological analysis were also collected. Material was preserved in bottles saturated with 70 per cent. ethyl alcohol vapour. There was no need for actually pickling the material in 70 per cent. alcohol, and the method adopted proved extremely successful. Anthers

* Paper read at the Indian Science Congress, Calcutta, 1957.

were tested on a slide with a drop or two of 1 per cent. aqueous solution of iodine in potassium iodide to which was added a few ml. of glycerine to prevent rapid evaporation on the slide. All the pollen grains which took the stain either by turning complete blue, or showing slight positive reaction to iodine were considered as fertile and only those which were completely empty and shrivelled up were considered to be abortive.

Photomicrographs were taken with a Zeiss Winkel photomicrograph attachment camera with panchromatic film.

Results

In the variety *Zimmer Spanish* 19 plants were analysed. Out of these only eight plants showed cytological aberrations. Table I shows the details of observation for these eight plants:—

Table I

Cytological data for Zimmer Spanish

No.	Diakinesis	Metaphase	Anaphase and Telophase	Total No. of sporocytes analysed	No. showing aberration	Per cent. sporocyte aberration	Observed per cent. pollen abortion
1	24^{II}	Normal	Laggards and bridges	242	36	14·9	18·3
2	do.	do.	do.	352	68	19·7	21·8
3	do.	do.	do.	128	13	10·15	16·4
4	do.	do.	do.	176	23	13·06	16·2
5	do.	do.	do.	226	26	11·50	18·5
6	do.	do.	do.	146	18	12·32	17·5
7	do.	do.	do.	304	42	13·81	18·8
8	do.	do.	do.	343	38	11·07	17·5
					Average..	13·31	18·1

II. Comstock Spanish

Out of the 11 plants analysed only three showed aberration. The data are tabulated below in Table II.

The very low percentage of cells showing abnormality is probably due to the non-availability of the critical stages for examinations. However, pollen analysis reveals a larger percentage of sterility. Nevertheless, even this high percentage does not exceed 16·4. In other material the percentage approximates 20. In *Comstock Spanish*, there was a high proportion of partially filled grains which it was thought appropriate to group as fertile in view of the fact that in most plants, partially filled grains are slightly immature and starch formation is incomplete.

TABLE II

Cytological data for Comstock Spanish

No.	Diakinesis	Metaphase	Anaphase and Telophase	Total No. of sporocytes analysed	No. showing aberration	Per cent. sporocyte aberration	Observed per cent. pollen abortion
1	24^{II}	Normal	Laggards and bridges	208	11	5·28	14·2
2	do.	do	Laggards and bridges. One sporocyte showed a chain of 4 in diakinesis	300	22	7·33	16·4
3	do.	do.	do.	400	15	3·75	10·6
					Average	5·45	13·7

III. PENNSYLVANIA SEED LEAF-GREIDER

Out of a total of 17 plants analysed only 8 plants showed low sterility. Samples from 2 of the plants were too young for cytological observation. Data are given in Table III:—

TABLE III

Cytological data for Pennsylvania Seed Leaf-Greider

No.	Diakinesis	Metaphase	Anaphase and Telophase	Total No. of sporocytes analysed	No. showing aberration	Per cent. sporocyte aberration	Observed per cent. pollen abortion
1	24^{II}	Normal	Laggards and bridges	232	38	16·37	21·7
2	do.	do.	do.	264	34	12·87	20·3
3	do.	do.	do.	214	42	19·62	21·8
4	do.	do.	do.	183	32	17·48	21·7
5	do.	do.	do.	126	18	14·28	20·6
6	do.	do.	do.	246	24	9·75	20·8
7	do.	do.	do.	273	56	20·51	22·5
8	do.	do.	do.	144	26	18·05	22·6
					Average ..	16·11	21·5

IV. Connecticut Broad Leaf × Comstock Spanish

Progenies from this cross were tested. Only two samples out of 7 showed aberrations.

Table IV

Cytological data for Connecticut Broad leaf × Comstock Spanish

No.	Diakinesis	Metaphase	Anaphase and Telophase	Total No. of sporocytes analysed	No. showing aberration	Per cent. sporocytes aberration	Observed per cent. pollen abortion
1	24^{II}	Normal	Laggards and bridges	206	27	13·10	18·7
2	do.	do.	do.	186	23	12·36	16·8
					Average..	12·73	17·75

V. Havana 142

Out of a total of 10 plants analysed 4 showed cytological aberrations.

Table V

Cytological data for Havana 142

No.	Diakinesis	Metaphase	Anaphase and Telophase	Total No. of sporocytes analysed	No. showing aberration	Per cent. sporocyte aberration	Observed per cent. pollen abortion
1	24^{II}	Normal	Bridges	482	76	15·76	18·9
2	do.	do.	do.	356	72	20·22	23·4
3	do.	do.	do.	371	63	16·98	22·5
4	do.	do.	do.	368	59	16·03	20·4
					Average	17·24	21·3

A comparison of estimated sporocyte aberration and pollen abortion reveals that in all cases there is a general increase in the percentage of aborted pollen, there being no relation between sporocytes showing aberration and the ultimate pollen abortion. This may probably be due to the fact that, even though a larger number of sporocytes do have aberrations, the desired stages are not easily available for counting. For instance, it is probable that some of the sporocytes which had passed into the late telophase I and subsequent stages really had chromosomal aberrations which could not be detected. It may be noted that, in all the cases studied, excepting one, *i.e.* (Comstock

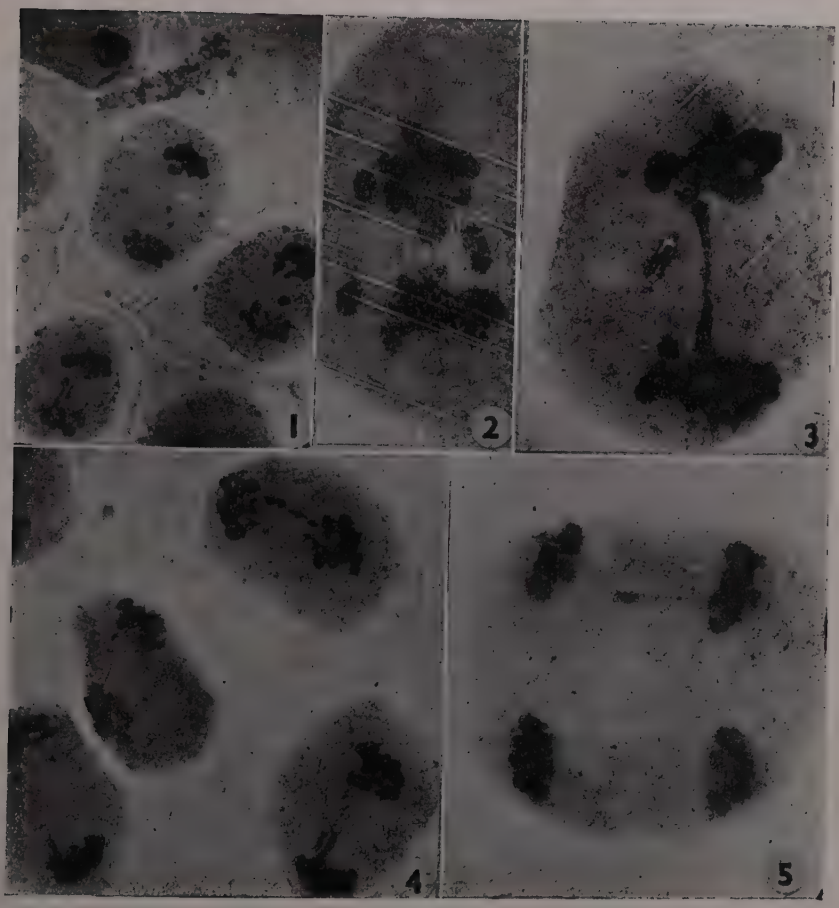
Spanish) where only one sporocyte showed a chain of four, diakinesis showed 24 bivalents.

Discussion and Conclusions

From the data it is clear that only a few plants in each culture showed pollen abortion and that in a low proportion. In certain other crops, particularly in maize and wheat, low male sterile lines are known to exist. Thus, Burnham (1932) reported a case of low sterile maize which was due to a chromosomal interchange between chromosome 6 and 1. Clarke and Anderson (1935) reported a similar case in which an interchange between chromosome 6 and chromosome 3 was involved, and in the heterozygous condition showed low sterility and small and partly filled pollen grains. The partly filled grains were interpreted as the result of duplication for the small piece of chromosome 3 *plus* the deficiency for the piece of satellite in chromosome 6. Smith (1948) observed that among a selfed progeny of plants of *Triticum monococcum* about 7 per cent. of plants showed low sterility which eventually was proved to be a deficiency duplication resulting from chromosomal interchange. In the present investigation it is not possible to ascribe the reason for low sterility definitely to any particular cause, but it is deduced from the cytological investigation that the probable cause of low sterility may be minute inversions. The probability that the sterility could be due to chromosomal interchange is ruled out because, in a homozygous condition, translocations do not usually result in any sterility at all, and a heterozygous translocation would theoretically give 50 per cent. sterility, and would show ring formation in diakinesis. On the other hand, a paracentric inversion in a heterozygous condition would, consequent on a cross over in the inverted region, result in dicentric and acentric chromatids. In anaphase separation, these would result in the characteristic bridges and laggards. In the present study, the cytological observations revealed only bridges and laggards in Anaphase I (Pl. VIII, Figs. 1–5). Unfortunately, due to difficulties in obtaining and analysing good pachytene stages in *N. tabacum* it was not possible to detect inversion loops to support the inference.

It may be noted that in each culture only some plants showed low sterility while the others did not. If the assumption that sterility is due to minute paracentric inversions in a heterozygous condition be true, the reason for getting these inversion heterozygotes in an either normal or homozygous inversion population needs explanation. It appears very probable that all the plants in previous generations of the above cultures were having minute inversions in a homozygous condition, and, due to chance pollination, a few plants received the normal pollen from plants that did not have inversion, the resulting plants becoming heterozygous for the inversions.

Low sterility could result even from minute structural differentiations, *i.e.*, "cryptic structural changes"—as Stephens (1950) calls them; —but, this possibility could be considered only if no visible bridges and laggards had been found and yet a low pollen sterility had resulted. In the investigation under report no such case was found.



D. M. Gopinath FIGS. 1–5

It is, therefore, concluded that the low sterility manifest in the above-mentioned cultures of *N. tabacum* is probably due to minute inversions.

Summary

A cytological examination of 5 cigar varieties, *viz.*, *Zimmer Spanish*, *Comstock Spanish*, *Pennsylvania Seed Leaf-Greider*, *Connecticut Broad Leaf* × *Comstock Spanish*, and *Havana* 142 revealed bridges and fragments during anaphase I in approximately 13 per cent. of microsporocytes. There is a correspondingly low percentage—about 18·5 per cent. —of pollen abortion in all the varieties. The low sterility is attributed to paracentric inversions.

Acknowledgement

Grateful thanks are due to Dr. N. R. Bhat, PH.D. (Cantab), Director, Tobacco Research, for critically going through the manuscript and offering valuable suggestions.

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Explanation of Plate

Plate VIII

Photomicrographs of sporocytes showing the Chromosomal aberration in:

Fig. 1. Zimmer Spanish.

Fig. 2. Comstock Spanish.

Fig. 3. Pennsylvania Seed Leaf-Greider.

Fig. 4. Connecticut Broad Leaf × Comstock Spanish.

Fig. 5. Havana 142.

Note.—The leggards in 1, 2, 4, and 5 and the bridge in No. 3.

THE EMBRYOLOGY OF *BORRERIA HISPIDA* K. SCHUM. (=*SPERMACOCE HISPIDA* LINN.) (RUBIACEÆ)—A REINVESTIGATION

By M. Farooq

Department of Botany, Muslim University, Aligarh

(Received for publication on September 22, 1958)

Introduction

The embryology of *Borreria hispida* has been worked out by Raghavan and Srinivasan (1941). The authors have given a very brief and incomplete account and have left out some important details. Since my observations show some differences the record of these was considered desirable. The endosperm and seed structure have already been described in an earlier publication (Farooq, 1952).

Dr. Reayat Khan collected some material from Dacca (East Pakistan) and very kindly handed it over to me. Some collection was made locally. The material was fixed in formalin-acetic-alcohol and dehydrated in alcohol-xylol series. Embedding was done in paraffin. Sections were taken at 10 microns. Staining was done in safranin and fast green.

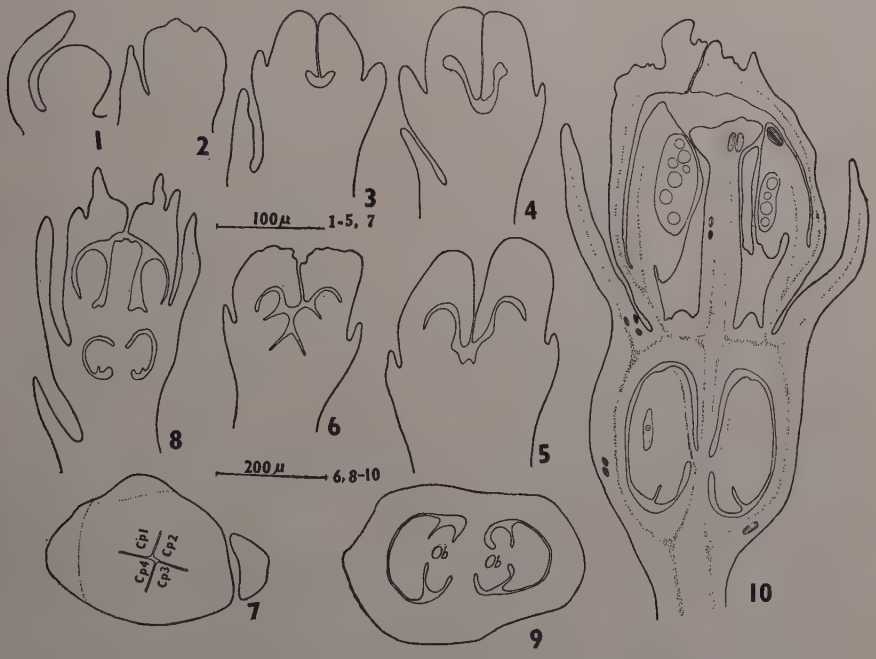
Organogeny

The floral bud arises as a spherical outgrowth in the axil of a bract (Text-Fig. 1). The differentiation of the calyx primordia is immediately followed by the hollowing out of the apical region of primordium. The rim surrounding the depression gives rise to four corolla lobes which arch over the pit (Text-Figs. 2–4). At the angles of the sinuses of the corolla lobes four knob-like primordia of the stamens originate (Text-Fig. 5). Alternating with the stamens, from the base of the corolla lobes, four elevations make their appearance. These grow centripetally and in a somewhat horizontal plane (Text-Figs. 6 and 7). Ultimately they meet with one another and roof over the cavity. From their point of contact they continue to grow upwards to form the solid style and the bifid stigma, and downwards to produce half of the septum of the ovary. Meanwhile an outgrowth develops at the base of the concavity of the receptacle. This grows upwards and meets the partition wall which is extended down from the roof. The ovary thus becomes bilocular (Text-Fig. 8). The basal outgrowth develops lateral extensions in two opposite directions, one in each locule, each of which is ultimately transformed into a hemi-anatropous ovule (Text-Fig. 8). Druses and raphides are very common in all floral parts (Text-Fig. 10).

Megasporangium and the Female Gametophyte

The ovules are hemianatropous, apparently unitegmic and tenuinucellate. The so-called "obturator" or "strophiola" makes its

appearance early in the development of the ovule and covers the entire proximal portion of the latter in a ring-like fashion (Text-Fig. 9). The vascular supply of the ovule terminates in the obturator. The archesporium is differentiated at an early stage of the ovule development. Raghavan and Srinivasan have stated that "the archesporium is enveloped by 2–3 cells which form the nucellar epidermis and these are crushed during the enlargement of the megaspore mother cell". In my material, the nucellar epidermis was sometimes 2-celled and most frequently it was only 1-celled. The archesporium also was 1-celled and rarely 2-celled. The nucellar epidermis persists until the non-functional megaspores have completely disappeared (Text-Fig. 13). Fagerlind (1937) has recorded the presence of nucellar epidermis in *Spermacoce tenuior* up to the tetrad stage.



TEXT-FIGS. 1–10. *Borreria hispida* K. Schum. Fig. 1. Young floral bud and the bract. Fig. 2. Initiation of Calyx lobes. Figs. 3 and 4. Corolla lobes arching over the depression. Figs. 5 and 6. The primordia of carpels and basal placenta. Fig. 7. T.S. of bud at the level of the four carpel primordia. Fig. 8. L.S. of bud showing fusion of basal placenta and septum and the solid style. Fig. 9. T.S. of ovary showing the position of obturator. Fig. 10. L.S. of bud showing the heminatropous ovule and other floral parts. (*Ob*, Obturator; CP_1, CP_2, CP_3, CP_4, Carpel primordia).

The archesporial cell directly functions as the megaspore mother cell producing usually a linear tetrad (Text-Fig. 11). In one exceptional case the dyads were found dividing in such a plane that they would have given rise to a ⊥-shaped tetrad (Text-Fig. 12). As recorded

by Raghavan and Srinivasan (1941), the embryo-sac is monosporic, 8-nucleate with the normal organization of egg and antipodal apparatus. The arrangement of the antipodals is linear or triangular. The lowermost antipodal is the biggest. According to Raghavan and Srinivasan the antipodals degenerate after fertilization. However, I have found healthy antipodals in embryo-sacs of *B. hispida* which contained more than two hundred endosperm nuclei and the proembryo was 9-celled, disposed in 8 tiers (Text-Fig. 14). These antipodals possessed prominent nuclei and their cytoplasm contained starch grains. The antipodals of *B. hispida* closely resemble in form and function those of *Callipeltis*, *Asperulla*, *Diodia*, etc. (Lloyd, 1902).

In one exceptional ovule twin embryo-sacs were present (Text-Fig. 15). Both were at 8-nucleate stage. In one of them organization of egg apparatus and antipodals had taken place while in the other 4 nuclei were present at either pole without any organization. It is difficult to say whether they had developed from 2 megaspores of a single tetrad or from megaspores belonging to different tetrads.

Microsporangium and the Male Gametophyte

After the differentiation of the sporogenous layer and primary wall layer, the latter undergoes a periclinal division to produce two layers. The inner of these two develops into the tapetum while the outer divides to produce the endothecium and the middle layer (Text-Figs. 16–19). At maturity the middle layer becomes crushed and disappears, and the wall of the anther consists of the epidermis, the endothecium with usual thickenings and the degenerating tapetum. Raghavan and Srinivasan write, "At the mature stage the wall of the anther sac consists of only three layer of cells (Text-Fig. 4). In addition to the three wall layers, a tapetal layer is differentiated from the innermost layer of wall cells (Text-Fig. 4)". But the figure really shows an anther with microspore mother cells. The tapetum in *B. hispida* is of secretive nature. The tapetal cells become vacuolated and bulge out into the pollen chamber. Raghavan and Srinivasan have recorded that the nucleus of the tapetal cells divides mitotically and daughter nuclei thus formed fuse with one another to give rise to a nucleus with two nucleoli and where three nucleoli are present, possibly they had been formed by the fusion of two nucleolated nucleus with an ordinary nucleus. In my material, the tapetal cells remain uninucleate throughout. The division of the microspore mother cells is synchronous. The wall of the mother cell persists during the meiotic divisions (Text-Figs. 20 and 21). The cytokinesis is simultaneous and the division occurs by centripetally advancing constriction furrows which meet in the centre and give rise to four microspores (Text-Figs. 22 and 23). The microspore tetrads may be tetrahedral or decussate (Text-Figs. 24 and 25). The microspores are big in size, measuring about 60 microns. In meridional section they are biconvex in shape (Text-Figs. 26 and 28) and in equatorial section they appear circular with 13–15 elevation (Text-Fig. 27). At the shedding stage the microspore is 3-nucleate and full of starch grains and becomes almost spherical in outline (Text-

Fig. 29). The shape and size of the mature pollen resemble very much those of *Richardsonia pilosa* pollen (Fagerlind, 1937). The nuclei of several pollen grains, in which generative cell had been formed, possessed more than one nucleolus (Text-Fig. 30). The presence of multinucleolated nuclei in diploid as well as in haploid cells is a characteristic feature of the plant.

A case of polyspermy was noted in a grain which possessed one large chromatin body corresponding to the vegetative nucleus and four small bodies equivalent to four sperms (Text-Fig. 31).

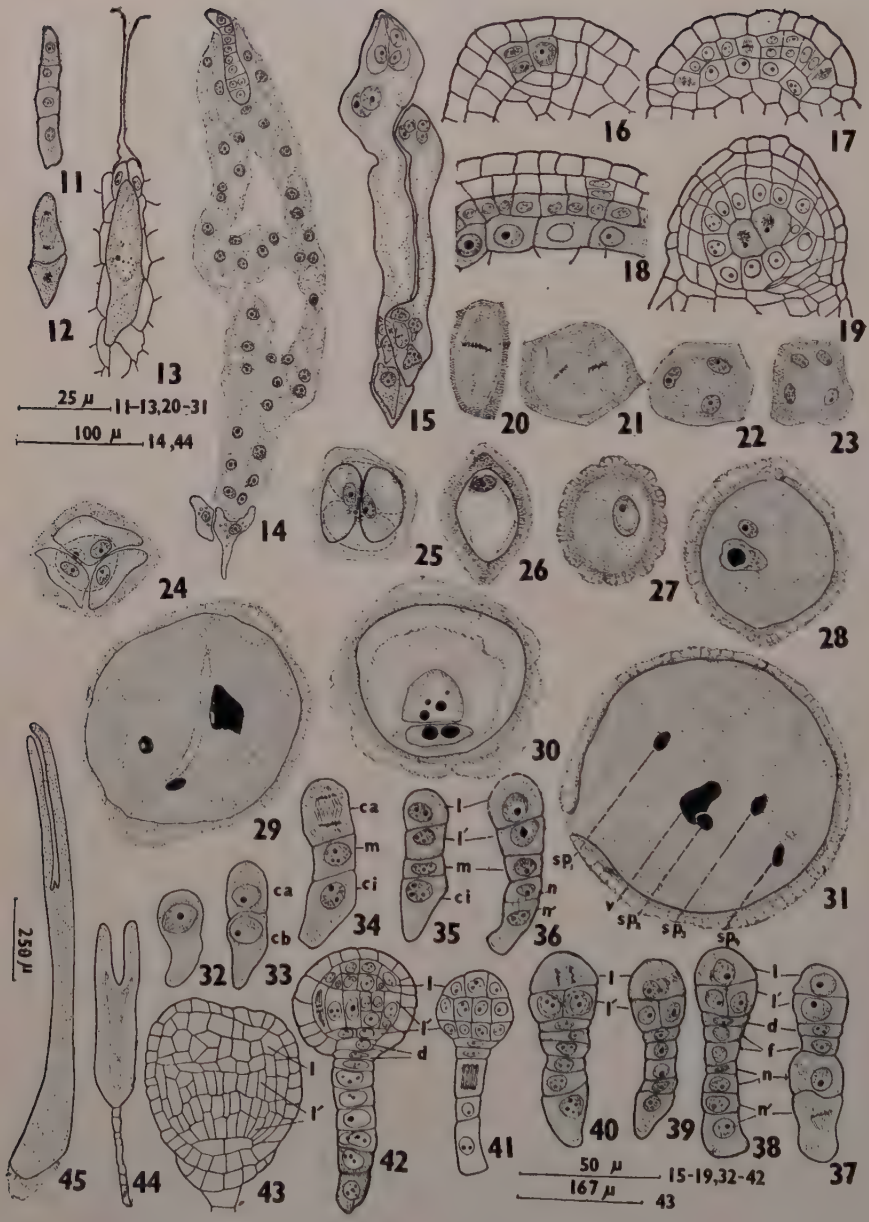
The Endosperm

The endosperm is free nuclear (Farooq, 1952). An interesting phenomenon has been noted in the development of the endosperm of *B. hispida*. At about the time of wall formation in the endosperm the protoplasm encloses a big central cavity. Then almost from the middle region of the endosperm a protoplasmic diaphragm is seen to divide the endosperm cavity into micropylar and chalazal halves (Text-Fig. 14). Later on both the cavities thus formed are completely filled with the protoplasmic substance, but nuclei are totally absent from this region. Ultimately the entire endosperm becomes homogeneous and cellular.

Fertilization and Embryogeny

The pollen tube creeps over the obturator and finally enters the embryo-sac through the micropyle. Usually both the synergids are destroyed during the entry of the pollen tube into the embryo-sac.

The zygote (Text-Fig. 32) divides when several endosperm nuclei have been formed. The first division of the zygote is transverse and the terminal cell '*ca*' and the basal cell '*cb*' are produced (Text-Fig. 33). The cell *cb* divides transversely to give rise to the cells *m* and *ci* and *ca* to the cells *l'* and *l* (Text-Figs. 34 and 35). Then *ci* produces the cells *n* and *n'* and *m* produces *f* and *d* (Text-Figs. 36 and 37). Further divisions of the cells *n*, *n'* and *f* give rise to variable number of cells which constitute the uniseriate suspensor. When the proembryo has reached 7–9-celled stage, the cell *l'* divides vertically, followed by a vertical division of the cell *l* (Text-Figs. 38 and 39). The walls laid down between the daughter cells of *l* and *l'* may be in the same plane or at right angles to one another. The division of daughter cells of *l'* precedes that of *l* (Text-Fig. 40). The hypocotyl and the root are derived from the daughter cells of *l'* and the cotyledons and plumule develop from the product of divisions of the cell *l* (Text-Figs. 41–43). The products of the cell *d* produce the root cap. Thus the embryogeny of *B. hispida* conforms to the Solanad type (Souèges, 1920, 1922). The suspensor consists of 8–10 cells (Text-Fig. 44). Haustorial appendages are absent. One or two uppermost cells of suspensor possess prominent nucleus and dense cytoplasm (Text-Figs. 42 and 44). They might possess some haustorial property. Similar condition has been recorded



TEXT-FIGS. 11–45. *Borreria hispida* K. Schum. Fig. 11. Linear megaspore tetrad. Fig. 12. Dyads dividing to produce T-shaped megaspore tetrad. Fig. 13. L.S. of ovule showing uninucleate embryo-sac, two cells of nucellar epidermis and the micropyle. Fig. 14. L.S. of embryo-sac showing the protoplasmic diaphragm dividing the central cavity of the endosperm, 9-celled embryo and the persistent anti-

podals. Fig. 15. Twin embryo-sacs. Figs. 16–19. Formation of wall layers of the anther. Figs. 20–23. Division and cytokinesis in the formation of microspores. Figs. 24 and 25. Tetrahedral and decussate microspore tetrads. Fig. 26. Meridional section of a one nucleate pollen grain. Fig. 27. Equatorial section of a one nucleate pollen grain. Fig. 28. Two nucleate pollen. Fig. 29. Mature pollen grain with two sperm nuclei and one vegetative nucleus. Fig. 30. Two nucleate pollen with abnormally large nuclei. Each nucleus has more than one nucleolus. Fig. 31. Pollen with four sperm nuclei and one vegetative nucleus. Fig. 32. Zygote. Fig. 33. The cell *ca* and *cb* formed by transverse division of the zygote. Figs. 34 and 35. Production of the cells *ci*, *m*, *l'*, and *l*. Fig. 36. Formation of the cells *n* and *n'*. Fig. 37. 6-celled proembryo. Fig. 38. Longitudinal division of the cell *l'*. Fig. 39. Quadrant stage of the embryo. Fig. 40. Formation of octant stage of the embryo. Figs. 41 and 42. L.S. of sphere stage of embryo. Fig. 43. Longitudinal section of heart-shaped embryo. Fig. 44. L.S. of embryo showing cotyledons, hypocotyl, root and root cap. The lowermost suspensor cell bears haustorial characteristics. Fig. 45. L.S. of mature embryo. (*ca*, *cb* product of zygote; *ci*, *m*, product of *cb*; *n*, *n'* products of *ci*; *f*, *d* product of *m*; *l*, *l'* products of *cb*; sp_1, sp_2, sp_3, sp_4, sperm nuclei; *V*, Vegetative nucleus.)

in *Richardsonia* and *Leptodermis* by Fagerlind (1937). The mature embryo consists of root, two cotyledons and plumule (Text-Fig. 45).

Discussion

The number of carpels in the gynæceum of Rubiaceæ varies from 10–2 (Hooker, 1882) showing a tendency towards reduction. The gynæceum of *B. hispida* possesses two stigmas and two locules and it has been described as "2-celled". The presence of four carpel primordia suggests that the gynæceum in *B. hispida* may be described as tetracarpellary, syncarpous and bilocular. It is to be noted that in taxonomic descriptions of gynæceum, which is based on mature structure, it is better to say that the gynæceum is "2-celled" rather than "bicarpellary" or "tetracarpellary", etc. The number of cells often may not correspond to the number of carpels. Similarly, the number of stigmas and cells may not correspond to each other as seen in Graminæ and Compositæ. The mature gynæceum in *B. hispida* may be described as 2-celled although developmentally it may be regarded as tetracarpellary. This will be in line with the general trend for reduction in the number of carpels.

In the ovules of many Rubiaceæ a special formation develops towards the funicular side. Lloyd (1902) has reported the presence of such formation in *Richardsonia* and *Diodia* and calls it 'strophiola'. Goebel (1923) calls all the accessory covers of ovules as 'arillus', but Wettstein (1924) reserves this term only for the formations which develop after fertilization and those which develop earlier have been called *strophiola*. The latter are met with in different families, have different structures and are assigned different functions. The strophiola of different families cannot be considered homologous structures. In the Rubiaceæ strophiola is sometimes considerably bigger than the rest of the ovule and almost completely encloses the latter; only a small portion of the surface of the integument is left free in *Tricalysia* (Fagerlind's Fig. 19 *i*). In *B. hispida* the strophiola no longer retains the appearance of a cover. It covers the surface of the ovule which

faces the ovarian septum and almost reaches the micropylar opening. The obturator in *Putoria* and *Phyllis* (Fagerlind, 1936 *a*, *b*) is homologous with the strophiola, but it is reduced. In *Psychotria emetica* the strophiola appears as an unimportant swelling. Fagerlind (1937) assumes that the strophiola, at least in the Rubiaceæ, is a second integument. The condition in *Pavetta* and *Tricalysia* seems to support this view because in these genera the resemblance to integument is even more pronounced.

According to Fagerlind the archesporial tissue and nucellar epidermis in *Spermacoce tenuior* conform to the Bouvardia type. But the condition met with in *B. hispida* is intermediate between Oldenlandia type and Bouvardia type, as the nucellar epidermis and the archesporium is usually 1-celled and occasionally 2-celled. The cells surrounding the dyads and tetrads become elongated and are finally crushed during the enlargement of the megaspores and the embryo-sac. The antipodals in *B. hispida* are well developed and are retained till advanced stages of embryo and endosperm development. They have been recorded in *Vaillantia* until cell walls are formed in the endosperm and they function as haustoria.

Håkansson (1923) has pointed out that in Umbellifloræ the tapetum and the middle layer of the anther wall are sister layers. It is usually assumed that Umbellifloræ and Rubiales are closely related. Therefore, Fagerlind (1937) considered it to be of importance to observe the formation of the wall layers of anther in the Rubiaceæ. In all the plants of the Rubiaceæ which have been studied in this respect, *viz.*, *Galium*, *Bouvardia*, *Houstonia* and *B. hispida*, the formation of wall layers follows the normal course.

In the family Rubiaceæ, the Cinchonoideæ usually have small microspores but in Coffeoideæ the pollen grains are often big, *viz.*, *Psychotria*, *Richardsonia*, *Borreria hispida* and *Myrmecodia*.

The endosperm is free nuclear in all the Rubiaceæ whose life-history has been worked out except *Ophiorrhiza mungos* (Ganapaty, 1956). The development of the protoplasmic diaphragm across the endosperm cavity is noteworthy.

Summary

1. The organogeny has been described. The presence of four carpel primordia suggests that the 2-celled condition has been derived by reduction from a tetracarpellary gynæceum. The ovules are hemianatropous, unitegmic and tenuinucellate.

2. The nucellus is represented by one or two epidermal cells. Usually the archesporium is 1-celled, sometimes 2-celled. The archesporial cell directly functions as megaspore mother cell.

3. The megaspore tetrad is usually linear. The embryo-sac is monosporic and 8-nucleate and the antipodals are retained for a long time after fertilization.

4. Sometimes twin sacs may develop.

5. The pollen grains are 3-nucleate at the time of shedding. A case of polyspermy was noted.

6. The endosperm is nuclear. Before wall formation the endosperm cavity is divided into two parts by the development of a protoplasmic diaphragm.

7. The embryogeny follows the Solanad type. The suspensor is long and the uppermost one or two cells possess the appearance of haustorial cells.

I am grateful to Prof. P. Maheshwari for suggesting the problem and guidance. I am also indebted to Dr. Reayat Khan for his help in writing the account.

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FLORAL ANATOMY OF MELIACEÆ—II*

By L. L. Narayana

Osmania University, Hyderabad-7

(Received for publication on October 30, 1958)

Introduction

The floral anatomical work in the family Meliaceæ has been summarized by the writer in his previous article (L. L. Narayana, 1958 *b*).

The present paper deals with the floral anatomy of *Turræa heterophylla* Sm., *Soymida febrifuga* Adr. Juss., *Chloroxylon swietenia* DC. and *Hynea trijuga* Roxb.

Materials and Methods

All the materials were fixed in F.A.A. Customary methods of dehydration, infiltration and embedding were followed. Serial transverse sections of flower buds were cut at a thickness of 6–12 microns. Crystal violet and Erythrosin combination was used for staining the sections.

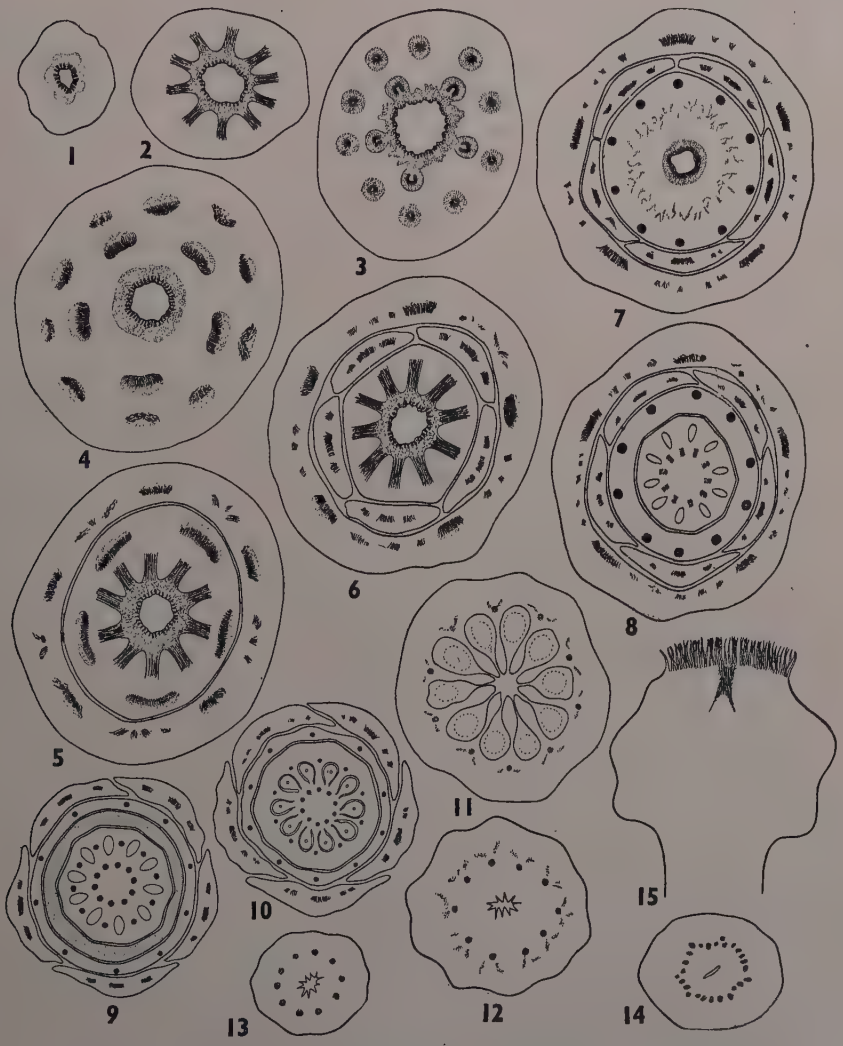
Observations

Turræa heterophylla.—The flower has 2 pentamerous whorls of perianth of which the calyx is gamosepalous (Text-Figs. 5–8). The stamens are united into a tube from which the anthers separate at the top. The hypogynous disc is adnate to the base of the androœcium tube (Text-Figs. 8 and 9). The ovary is 10-carpellary, syncarpous, 10-locular at the base and unilocular above (Figs. 9–11). The style is long and the stigma bears numerous unicellular hairs (Text-Fig. 15).

The pedicel shows a siphonostele (Text-Fig. 1). Ten traces arise from the main stele (Text-Fig. 2) of which 5 represent the sepal midribs and the alternating 5 are the conjoint sepal laterals (Text-Fig. 3). The bundles supplying the perianth parts, particularly the midrib bundles expand fanwise, branch and form a number of strands in each perianth member (Text-Figs. 4–10). Next, from the main stele ten staminal traces arise in one whorl (Text-Figs. 5 and 6) and enter the base of the staminal tube which soon separates from the thalamus (Text-Fig. 8). The staminal traces as they proceed towards the periphery give off branches (Text-Fig. 7); these fade away in the thalamus region without entering the disc, which as in *Cipadessa baccifera* (Narayana, 1958 *a*) is adnate to the base of the staminal tube (Text-Figs. 8 and 9). The main stele then becomes a continuous ring (Text-Fig. 7). No dorsal carpellary traces are demarkated. At the level

* Work completed at the Andhra University.

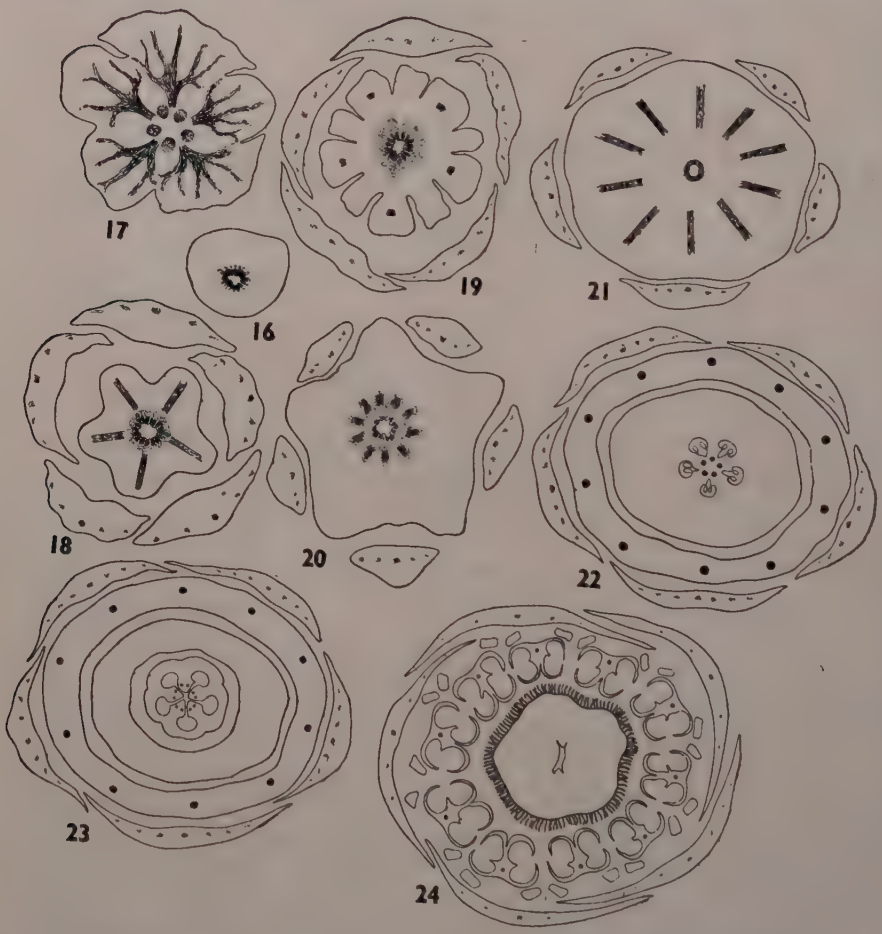
at which the bases of the loculi appear ten conjoint median dorsal traces are given off into the septa (Text-Fig. 9). The remaining part of the stele breaks up into ten common ventrals which lie on the septal radii (Text-Figs. 9 and 10). These are consumed in the ovular supply. The median dorsals give off some branches which fade away towards the top of the ovary (Text-Figs. 11 and 12). They extend to the top of the style where they branch and form a number of small strands (Text-



TEXT-FIGS. 1–15. *Turræa heterophylla.* For explanation see text. Figs. 1–10 and 14, ×14. Figs. 11, 12, 13 and 15, ×23.

Fig. 14). The style shows a canal with ten radiating arms which represent the extensions of the loculi (Text-Fig. 13).

Soymida febrifuga.—The flower is dichlamydeous and pentamerous. The androecium consists of 10 stamens, monoadelphous; the staminal tube splits up into 20 teeth at the top (Text-Fig. 24). A massive hypo-

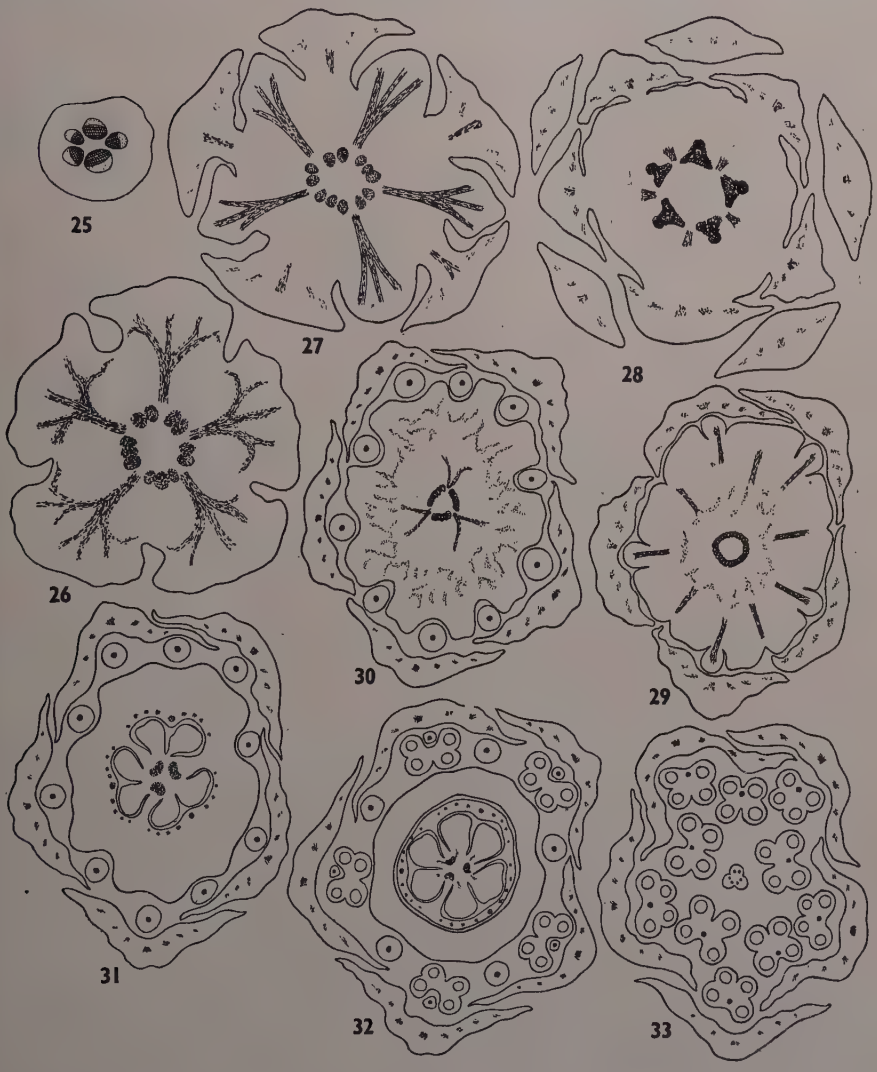


TEXT-FIGS. 16–24. *Syomida febrifuga*, ×14. For explanation see text.

gynous disc which is not adnate to the androecium or gynoecium is present (Text-Fig. 23). The ovary is 5-carpellary, syncarpous and 5-locular. The style is short and the stigma cleaves into 5 antepetalous lobes and bears numerous unicellular hairs (Text-Fig. 24).

The pedicel shows a ring of closely placed vascular bundles (Text-Fig. 16) from which 5 sepal traces arise (Text-Fig. 17). Each trace

divides to form a number of branches as it emerges (Text-Fig. 17). Next, the 5 petal traces arise (Text-Fig. 18); these divide into a number of petal bundles (Text-Figs. 18–24). The thalamus shows ridges between the bases of petals (Text-Fig. 19). From the main stele which is ring-like (Text-Fig. 19) the 10 staminal traces arise in one whorl (Text-



TEXT-FIGS. 25–33. *Chloroxylon swietenia*, ×18. For explanation see text.

Figs. 20 and 21). No dorsal carpellary traces are demarkated. The main stele is used up in the formation of 5 common ventrals which lie on the septal radii (Text-Fig. 22). Towards the top the ovary becomes unilocular. At this level the ventrals divide into two each. These,

however, fade away soon. No vascular tissue extends into the style which shows a narrow 5-angled canal. The unicellular stigmatic hairs show some deep staining bodies.

Chloroxylon swietenia.—The flower is pentamerous and pentacyclic. The stamens are 10 in number, free and are of two different heights (Text-Fig. 32). The ovary is 3-carpellary, syncarpous and 3-locular (Text-Figs. 31 and 32). A hypogynous disc is present (Text-Fig. 32). Unicellular hairs are present on the disc and the ovary wall. Raphides are present in the thalamus tissues. The style is 3-lobed (Text-Fig. 33); unlike in other members of Meliaceæ studied there are no unicellular stigmatic hairs.

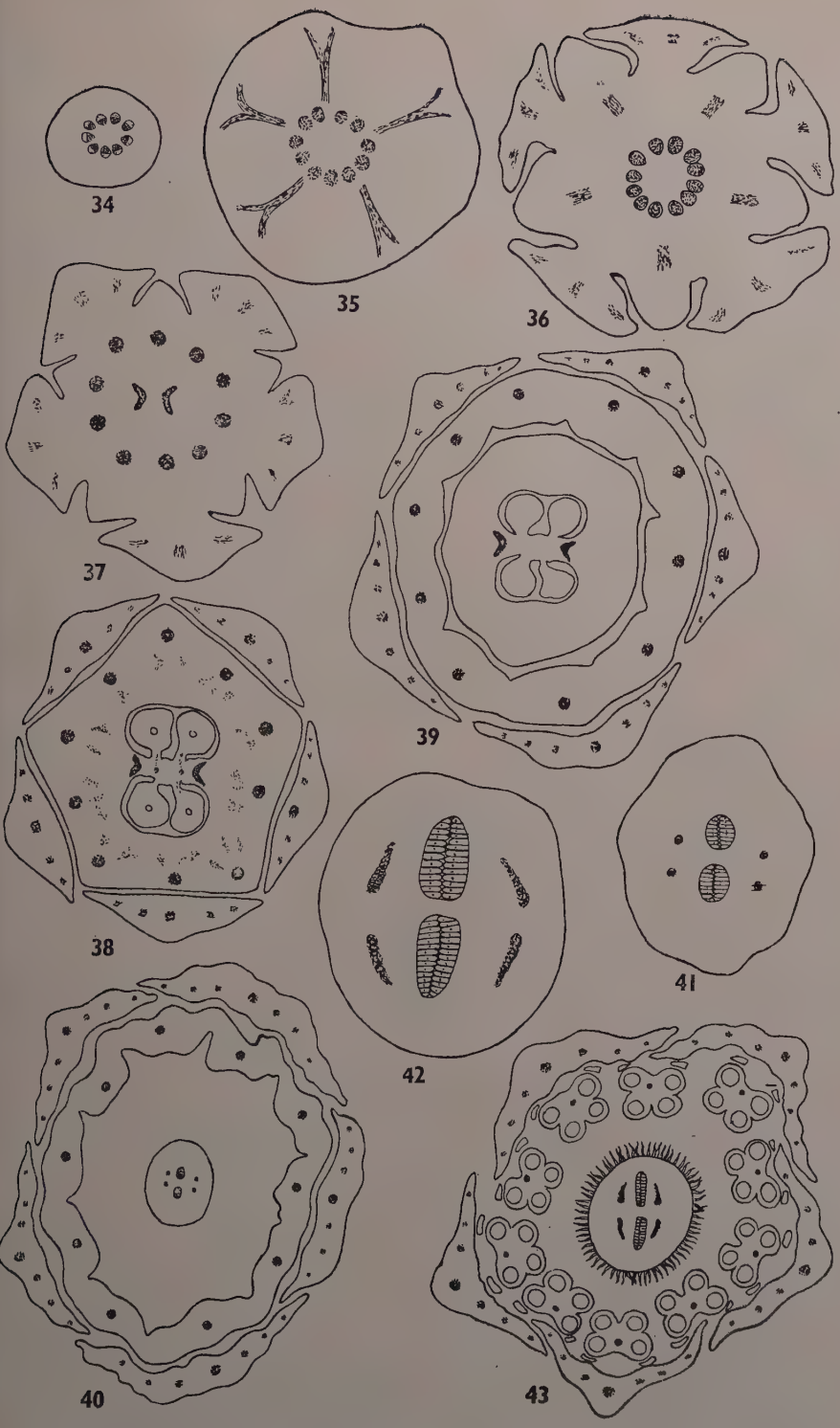
The pedicel in its structure shows a ring of discrete vascular bundles (Text-Fig. 25). From the ring of bundles in the thalamus, the 5 sepal and 5 petal traces are given off in two successive whorls (Text-Figs. 26 and 27). The traces for the antepetalous stamens arise and separate earlier than those of the antesepalous stamens (Text-Fig. 28). The staminal traces give off strands which ramify and fade out in the base of the disc (Text-Figs. 29 and 30). Next the three dorsal carpellary traces arise (Text-Fig. 30) and give off smaller branches into the ovary wall (Text-Figs. 31 and 32). The remaining part of the main stele forms 3 common bundles which lie on the septal radii (Text-Figs. 31 and 32). These give off ovular traces and continue into the style where each divides into two (Text-Fig. 33).

Hynea trijuga.—The flower in this species resembles that of *Walsura piscidia* (Narayana, 1958 *b*). It has a dichlamydeous perianth, 10-stamens and a bicarpellary pistil with two ovules in each loculus (Text-Figs. 38 and 39). The disc is adnate to the base of the ovary. The stigmatic region bears numerous unicellular hairs (Text-Fig. 43).

The pedicel shows a ring of vascular bundles (Text-Fig. 34). The traces for the perianth members arise from the main stele of the thalamus in two successive whorls of 5 each and branch within the respective members they supply (Text-Figs. 35–40 and 43). The main stele organizes into 10 bundles which represent the staminal supply and two plexes towards the inside which represent the carpel supply (Text-Fig. 37). The staminal traces give off smaller branches which fade away early (Text-Fig. 38). As in *Walsura* (Narayana, 1958 *b*) no dorsal carpellary traces are demarkated. The ventral bundles are organized from the two plexes and these function as the ovular traces (Text-Fig. 38). The two plexes continue into the style where each splits into two (Text-Figs. 40 and 41) and give off a few closely placed branches towards the top of the style (Text-Figs. 42 and 43). Each loculus extends into the style as a narrow canal which is lined by glandular transmitting tissue (Text-Figs. 40–43).

Discussion

The flower in Meliaceæ is pentamerous and pentacyclic with a tendency towards reduction in the number of floral parts and their traces.



TEXT-FIGS. 34–43. *Hynea trijuga*. For explanation see text. Figs. 34–40 and 43, ×28. Figs. 41 and 42, ×75.

The sepals are 1-traced in *Soymida*, *Chloroxylon* and *Hynea* and the marginals are separate. In *Turræa* the sepals are 3-traced with conjoint marginals. This condition seems to have arisen by a condensation of the internode.

The petals in *Turræa*, *Soymida*, *Chloroxylon* and *Hynea* are single-traced as in other investigated species of Meliaceæ (Narayana, 1958 *a* and *b*).

Typical obdiplostemony is present in *Chloroxylon* in which the traces for the antepetalous stamens are detached earlier than those of the antesepalous stamens. In *Turræa*, *Soymida* and *Hynea* all the 10 staminal traces are organized in one whorl, probably due to a condensation of the thalamus region. Branching of staminal traces is noticed in *Turræa*, *Chloroxylon* and *Hynea* while in *Soymida* no branching is seen.

As in other members of Meliaceæ examined (Narayana, 1958 *a* and *b*) a disc is present in all the four species. It becomes separated from the thalamus in *Soymida* and *Chloroxylon*. In *Turræa* it is adnate to the base of the staminal tube, while in *Hynea* it is adnate to the base of the ovary. The disc is fed by the branches given off by the staminal traces in *Chloroxylon*. In *Turræa* and *Hynea* the branches given off by the staminal traces fade away in the thalamus region and do not enter the disc.

In *Turræa* the ovary is 10-carpellary, syncarpous; 5-carpellary syncarpous in *Soymida*; 3-carpellary syncarpous in *Chloroxylon* and 2-carpellary syncarpous in *Hynea*. Conspicuous branched dorsal carpellary traces are found only in *Chloroxylon*. In *Turræa*, *Soymida* and *Hynea* dorsal carpellary traces are not demarkated. Median dorsals are noticed only in *Turræa*. The two vascular plexes seen on either side of the ovary in *Hynea* seem to represent the condensed vascular systems of the two carpels. In *Chloroxylon* the ventrals continue into the style after supplying the ovules while in *Turræa*, *Soymida* and *Hynea* they are completely used up in the ovular supply. Thus we can trace a reduction in the number of carpels as well as in their traces.

The placentation in all the four species is anatomically parietal.

The systematic position of the genus *Chloroxylon* is disputed. It was included in Rutaceæ by Engler and Prantl (1931), while Bentham and Hooker (1862–93) included it in Meliaceæ in the tribe Cedrelæ along with *Cedrela* and *Flindersia*. Basing on the study of wood anatomy of *Chloroxylon swietenia* Hedayetulla and Chakravorty (1942) supported the position in Rutaceæ given by Engler and Prantl (1931).

The floral anatomy of *Chloroxylon* shows certain features of resemblance to members of Meliaceæ as well as to Rutaceæ. In the origin and emergence of staminal traces there is particular resemblance to *Cedrela*. There are 10 staminal traces in both genera organised in an obdiplostemonous manner. However, while all the 10 stamens are fertile in *Chloroxylon*, the antepetalous stamens in *Cedrela* are suppressed.

The dorsal carpellary traces in both genera show branching. The ventrals extend into the style where they divide into two each.

However, *Chloroxylon* differs from *Cedrela* and other Meliaceæ in the following features: the absence of stigmatic hairs; abundance of raphides in the thalamous; presence of glands in the thalamus and floral parts. In the last feature *Chloroxylon* resembles Rutaceæ-like *Glycosmis* (author's unpublished observations).

Summary

The floral anatomy of *Turræa heterophylla*, *Soymida febrifuga*, *Chloroxylon swietenia* and *Hynea trijuga* has been studied.

The sepals in *Turræa* are 3-traced and in *Soymida*, *Chloroxylon* and *Hynea* they are single-traced.

The petals in all the species are single-traced.

The stamens in *Chloroxylon* are free and the andrœcium is obdiplostemonous, while in *Turræa*, *Soymida* and *Hynea* it is monoadelphous and their traces arise in one whorl. Branching of staminal traces has not been observed in *Soymida*.

A disc is present in all the four species. It is adnate to the base of the staminal tube in *Turræa* and to the base of the ovary in *Hynea*. In *Soymida* and *Chloroxylon* the disc separates from the thalamus.

The number of carpels is 10 in *Turræa*; 5 in *Soymida*; 3 in *Chloroxylon* and 2 in *Hynea*. Branched dorsal carpellary traces are demarkated only in *Chloroxylon*. The ventrals in *Turræa*, *Soymida* and *Hynea* are used up in the ovular supply while in *Chloroxylon* they extend to the top of the style where they divide into two each. In *Turræa* the median dorsals extend into the style and these divide and form smaller branches towards its top.

The placentation is anatomically parietal.

Acknowledgements

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ABERRANT DIVISION OF THE MEIOTIC CHROMOSOMES IN *SORGHUM HALEPENSE* PERS.

By V. S. Raman and D. Krishnaswami

Agricultural Research Institute, Coimbatore

(Received for publication on November 19, 1958)

Introduction

Many meiotic abnormalities like desynapsis, stickiness and elimination of the chromosomes, failure of cytokinesis, etc., are known to be controlled by genetic factors. Others are induced by mere environmental conditions like extremes of temperature. The latter category includes all the above genic irregularities and such others as chromosomal aberrations, multipolar spindles, non-reduction and formation of diploid spores, etc. Several workers have artificially induced these abnormalities by the application of cold or hot treatment to the plants (Sax, 1937; Barber, 1941; Gustafsson and Nygren, 1946). Some irregularities noted in the meiosis of *Sorghum halepense* Pers. are described in this paper.

Material and Methods

The clump of *S. halepense* ($2n = 40$) under study was collected at Yercaud (Shevaroy hills, Madras State). The meiosis was studied in anthers squashed in propiono-carmine after fixing the panicles in propionic alcohol (1 : 3).

Observations

The course of meiosis was previously known to be normal in this plant forming regularly 20 bivalents. However, it was observed during March and April 1958 that many of the panicles did not set seeds. Investigations revealed that the meiosis was irregular in the panicles of most of the tillers.

The meiosis was invariably normal up to the I metaphase, when the 20 bivalents congress at the equator and a spindle is formed as usual. The disjunction at early I anaphase is also orderly (Pl. IX, Fig. 1) but during the movement of the daughter bivalents to the poles, the chromosomes start splitting very rapidly and are seen scattered throughout the entire spindle (Pl. IX, Fig. 2). The division was not simultaneous for all chromosomes and so the counts were not any exact multiples of the haploid number 20, but varied from cell to cell. The distribution of these teeming chromosomes to the poles is random and unequal (Pl. IX, Fig. 4). Sometimes two microsporocytes were seen to fuse together allowing free cytomixis (Pl. IX, Fig. 3). At I telophase,

many of the chromosomes were seen lagging (Pl. IX, Fig. 5) but ultimately most of them get included in the telophasic nuclei. Cytokinesis usually followed but sometimes failed (Pl. IX, Fig. 6). Metaphase plates at the second division were often unequal (Pl. IX, Fig. 6). The abnormal division of the chromosomes observed in I anaphase was not present in II anaphase. However, the distribution of chromosomes was again unequal to the poles. At II telophase, the nuclei were observed to be unequal in size and a few laggards were seen to be excluded in the cytoplasm (Pl. IX, Fig. 7). These laggards usually organize micronuclei at the tetrad stage (Pl. IX, Fig. 8). Abnormal tetrads and triads with unequal cells were observed in large numbers (Pl, IX, Figs. 9 and 10). The unequal distribution at II anaphase may be observed clearly. The mature pollen grains were shrunken and completely sterile (Pl. IX, Fig. 11).

Suppression of the Second Division

Another interesting abnormality was the suppression of the second division. The course of meiosis was normal up to early I anaphase and, as in the previous case, the anaphasic chromosomes divided very rapidly and became scattered in the spindle. At this stage, the microsporocyte undergoes fission, each daughter cell engulfing a random half of the scattered chromosomes (Pl. IX, Fig. 12). Each daughter cell rounds itself, the cell-wall thickens and the cytoplasm vacuolates giving the characteristic appearance of a pollen grain (Pl. IX, Fig. 13). Often the fission was incomplete resulting in diads of 'pollen grains' (Pl. IX, Figs. 14 and 15). The grains were all nonviable (Pl, IX, Fig. 16).

The clump was cut back to induce the growth of fresh tillers but later investigations revealed normal meiosis again in all the tillers during the flowering stage.

Discussion

The abnormalities described above seemed to be only temporary in the life of the plant and were apparently the reaction to environmental factors. Since these irregularities were noted in the hot months of March and April, 1958, it is reasonable to suppose that only the extreme heat could be responsible for the abnormalities in meiosis. The average maximum temperatures for the months of March and April, 1958, at Coimbatore were 34·9 and 34·8° C respectively and the absolute maximum temperatures were 36·8 and 36·7° C respectively.

While many tillers revealed these abnormalities, there were a few tillers in the clump which were regular in meiosis. Abnormalities in meiosis are induced by heat when the treatment is applied a few days before meiosis begins (Sax, 1937; Barber, 1941). So, the tillers that did not reveal the abnormalities in meiosis may probably be the ones that did not experience the heat at the vulnerable stage of development.

Sax (1937) has described several abnormalities induced artificially by hot and cold treatments in *Tradescantia paludosa*. But the aberrant

division of the anaphasic chromosomes reported here does not appear to have been recorded before.

Summary

Meiotic abnormalities in the clump of *S. halepense*, apparently induced by the summer heat, have been described. The meiosis was normal up to I metaphase but in anaphase, the chromosomes divide repeatedly and lie scattered in the spindle. Laggards, unequal distribution, failure of cytokinesis, abnormal tetrads, etc., have been described. In some cases, during the abnormal I anaphase stage, the microsporocyte underwent a simple fission, each daughter cell enclosing a random share of the teeming chromosomes. Each of the daughter cells rounded off into a pollen grain.

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Explanation of Plate IX

Fig. 1. Early I anaphase showing 11 bivalents intact and 9 pairs of daughter bivalents, ×800.

Fig. 2. I anaphase showing abnormal division of the daughter bivalents lying scattered in the spindle, ×800.

Fig. 3. Cytomyxis between the two microsporocytes, ×800.

Fig. 4. Laggards and unequal distribution of chromosomes in I anaphase, ×800.

Fig. 5. Laggards at I telophase, ×800.

Fig. 6. Unequal plates in II metaphase; failure of cytokinesis may be noted, ×800.

Fig. 7. Unequal nuclei and laggards in II telophase, ×800.

Fig. 8. Tetrad; a micronucleus may be seen in one of the cells, ×800.

Fig. 9. Abnormal tetrad with unequal cells, ×800.

Fig. 10. Triad in second anaphase; the third cell is due to faulty cytokinesis after the first division; unequal distribution of chromosomes may be noted, ×800.

Fig. 11. Shrunken, sterile pollen grains, ×770.

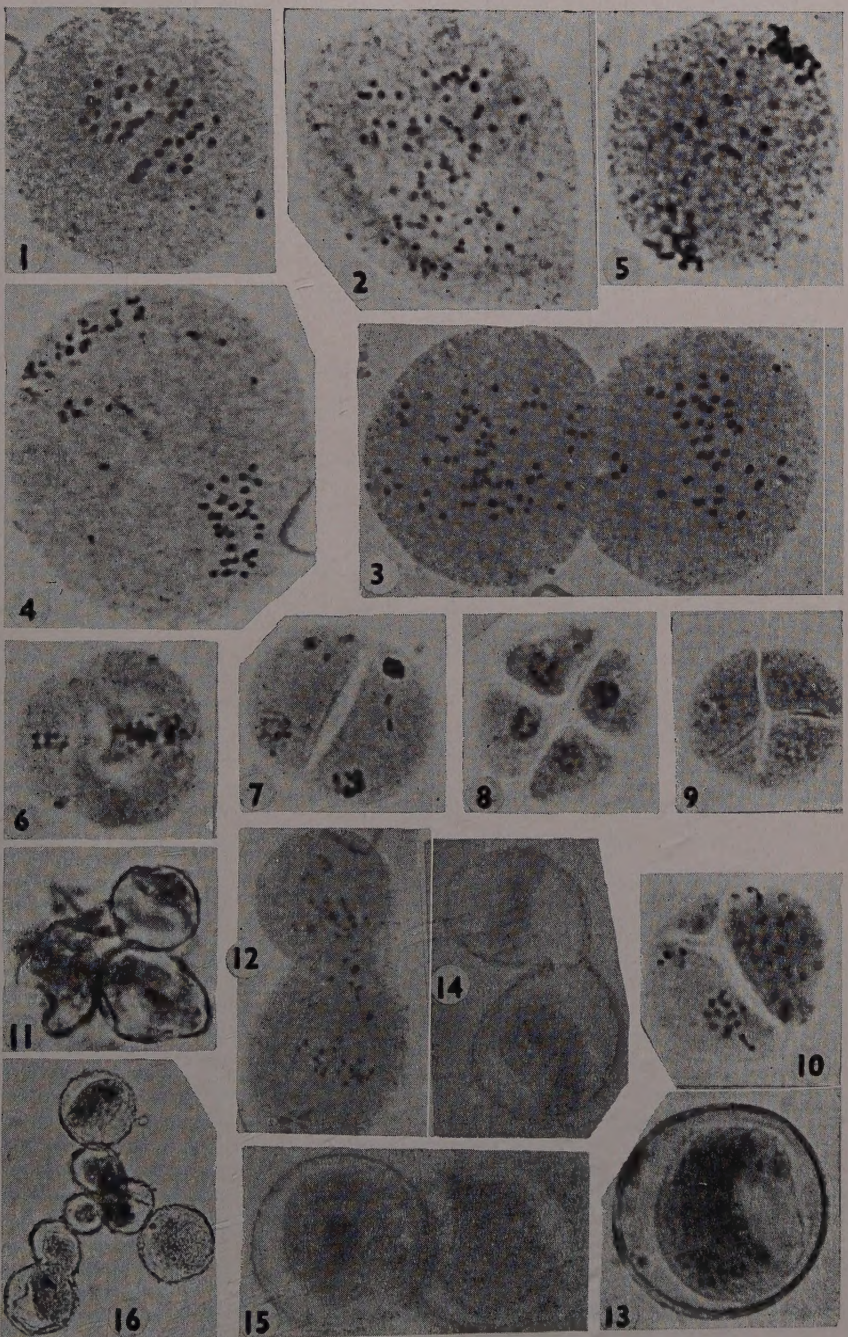
Fig. 12. Fission in I anaphase cell, ×800.

Fig. 13. Pollen grain formed after the suppression of second division; the heavy staining in the cytoplasm may be noted, ×770.

Fig. 14. Diad of pollen grains formed by incomplete fission, ×770.

Fig. 15. Same as above, ×770.

Fig. 16. Pollen grains, ×340.



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REVIEW

Modern Developments in Plant Physiology—Report of Seminar held in August 1957. Edited by P. MAHESHWARI and published by Botany Department of the University of Delhi. Pp. xi + 179.

We welcome this Report of a Seminar held in Delhi on the occasion of the visit to the country by Prof. K. V. Thimman, one of the outstanding Plant Physiologists. It opens with a foreword from him in which he has pointed out the need for the "purest" type of research for eliciting facts of "far-reaching applications". In the Inaugural Address, Dr. C. D. Deshmukh has drawn the reader's attention to the status of Plant Physiology in India and the serious limitation put to its investigational aspects through lack of proper equipment and personnel. He has also rightly pointed out the extent to which its frontiers could be and have expanded, *viz.*, biochemistry, biophysics and statistics.

It is gratifying to note that over fifty papers were read in the different sectional meetings on (i) Growth and Metabolism, (ii) Photoperiodism, Vernalisation and Growth Regulating Substances, (iii) Organ and Tissue Culture, (iv) General Physiology, (v) Physiology of Pollen, and (vi) Physiology of Fungi. The fact that more than fifteen papers deal either directly or indirectly with the effect of phytohormones and other growth regulators points to the multiplicity of the use to which these substances are put to in investigating diverse aspects of Plant Physiology. The focus of attention of the current investigations seems to be more on the growth regulators than on other major and minor constituents of plants.

All the sections included in the volume contain a few interesting papers. A stimulating paper under "General Physiology" deals on the correlation between ionic permeability of plasma and parasite resistance in plants. Other aspects of host-parasite relationship such as permeability to antibiotics/toxins produced by the fungal populations of the rhizosphere, heavy metal activation of enzymes, have been ably discussed in another paper and new light shed on the physiology of fungi. Another piece of work of academic as well as practical interest is that of herbicides on crop plants.

After going through the pages of this volume, the reader is, indeed, left with a well-justified satisfaction of being presented with a fairly comprehensive account of the several facets of physiological researches that are being carried out in India at the present time, despite serious set-backs caused by lack of facilities. However, it might be felt by those engaged in work in this branch of science that the volume would have been more complete if discussions ensuing the presentation of the paper had been included under each. This would not have made the volume unwieldy; it would have, on the other hand, given a fuller information of the proceedings of the Seminar to those of the readers who did not have the opportunity of attending the sessions.

J. V. BHAT.

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